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EDITORIAL

The Nation's Food

FEW people will dispute that one of the noblest tasks the men of science can undertake is the improvement of the food supply of the nation : few will deny that there are no men so well qualified to undertake this task. Chemists and biochemists have already done most valuable work and it is abundantly clear from the activities of the Food Group that a great mass of most important work is now engaging the scientific brains of the country : the four papers that we publish this week, recently read at the Newcastle meeting, deserve very careful attention : they deal with wheat, meat, milk, and fertilizers in connexion with the nation's food supply and they are contributed by experts who have devoted many years of experiment and study to their own special branches of the subject. The story that they have to tell is told simply and in an interesting manner : it is a complicated and fascinating story and we are proud that the Society is able to render some small service to the state by publishing these contributions. Meat, milk, and wheat, all come from the land, a material so varied and so constantly changing that an exact study of it requires many years of patient investigation. The transference of foods from this source to our great urban populations is the great problem of modern times : the problem upon the solution of which depends our economic existence, our commerce, and our modern civilization. Our industrial conditions are governed or automatically regulated by a sort of polygon of forces, always striving for a state of equilibrium. The more motor-cars the nation can make and sell at a profit, the more people will be employed and the more corn you must grow or import, the more demand there will be for milk, and eggs, and if the production of such foods is also profitable, the farmers will buy more horses, and gramophones, and tractors, and petrol, and so on. If the world were full of people there would be a constant struggle for existence and a survival of the fittest. Perhaps the farmer could survive when the chauffeur of the city doctor could not. We have not reached such a stage and probably never shall, but this is the usual state of what we may call the land. The soil itself is like a town, a structure of clay and sand with a teeming population of algæ, moulds, bacteria, protozoa, worms, insects, and other small creatures. These prey on decaying vegetable matter and on each other : the crop that grows on the surface may have to share the mineral constituents of the soil with a multitude of weeds : it may be cropped by sheep and other animals, or cut off and removed by man. A mixed crop, such as a modern pasture, may change its character entirely if in the early spring the flock is allowed to devour all the tender shoots of one genus and at a later season another genus is allowed to grow unmolested. Add to such competition the changes brought about by the rotation of crops and the use of artificial fertilizers and we easily recognize what a difficult story it is to tell. We require one sort of flour for the baker and another for the chickens, one sort of milk for A because he will have it so and another sort for B, the best beef from England or Scotland for the colonel, the cheapest beef from overseas for the private : we import much food and pay for a good deal of it by exporting soda, motor-cars, and indanthrene dyes. We are continually removing from the land potash, calcium, and phosphates in the shape of gallons of milk, legs of mutton, and rabbit pie, and are importing potash and phosphates to prevent the soil from becoming impoverished ; we need not import lime : there is plenty of it. The breeding of special varieties of cattle and cereals, the refrigeration of meat, fish, and fruit, their transport and sale, are matters that have received a far greater amount of attention from scientific men than is commonly believed. If you mention to the man in the street that you have been playing bridge with the chief chemist to a firm of brewers or distillers, he probably makes some facetious remark about chemicals taking the place of malt, instead of expressing gratitude to the chemist for only allowing the pleasantest and most kindly of ferments to occupy the vat, and seeing that they are well-fed, and kept nice and warm, and put to bed at the right time. The four papers we publish this week, excellent as they are, are just examples of the way the food problems of the country are being investigated here ; we have nothing but praise for the high standard of science so obvious at Rothamsted and Jealott's Hill, which we have visited more than once, and so abundantly proved at the many research stations that we have, to our regret, not yet visited.

HOW SCIENCE CAN HELP TO IMPROVE THE NATION'S FOOD SUPPLY—MILK AND DAIRY PRODUCTS*

By Dr. H. D. KAY

Supply and Effective Demand

I find it difficult to approach the subject of the improvement of the nation's food *supply* without regarding it, it may be confusedly, in respect of the nation's food *intake*. It seems to me, at least from the nutritional and human point of view, that to expend serious efforts on the improvement in the quantity and even in the quality of the nation's food supply is just piling one futility on to another if there is no prospect of an increased intake of these supplies, *i.e.*, either an increased *total consumption, or an increased consumption of high* quality products at the expense of those of low quality. It is sheer waste of time, endeavour, and material, to make Rolls-Royce cars, or build nine-roomed houses or even to produce certified milk for every family in the *country if none but a very small proportion of families* can afford to pay for them. No farmer really likes to have his wheat used as fuel, or his potatoes allowed to rot in the fields, nor does the planter take much delight in seeing his coffee burnt or his cotton destroyed.

"Says the pieman to Simple Simon 'Show me first your penny'; says Simple Simon to the pieman 'Indeed I have not any.'" The nation is at present to a large extent in the unfortunate position of Simple Simon who from the logical, purely business, point of view did not exist as a consumer since he was a consumer without purchasing power. Therefore at the outset of my *remarks I think it not out of place to say that much of* our work in the field of improvement of the nation's food supply is hampered by the financial inability of the would-be consumer to enjoy the fruits of our endeavours. It is idle to shut our eyes to these facts, or to regard *them as in any way outside the purview of the man of* science. These conditions may change for the better in the near future; we all sincerely hope they will. In fact this hope, conscious or sub-conscious, is the only valid reason for our being to-day. But even this limited purchasing power is at present being misapplied owing to lack of knowledge, or carelessness or both, on the part of the consumer. With this lack of knowledge is associated a tendency to be unduly influenced by the laudatory advertisement of foodstuffs which may be comparatively worthless from the nutritional point of view. Nevertheless we may *take some encouragement with regard to the slowly* increasing nutritional common sense of the purchaser from the fact that associated with the fall in the price of butter in the U.K. of between 8% and 10% in 1931 and 1932 the consumption of butter rose from 20·9 to 21·8 lb. per head, an increase of over 4%, despite the very severe fall in purchasing power. May we also draw from this a lesson in economics?

Specific Nutritive Value of Milk Products

Milk, and dairy products generally, occupy a specific position in the national bill of fare. Milk, in particular, is an almost complete foodstuff in itself, which is definitely *not true* for many of the articles which frequently loom larger in the family budget. I need not dilate extensively on this aspect to a group of chemists, but before leaving it I wish to point out one or two important aspects of the question, since they have considerable *importance with regard to the possible improvement* in the *quality* of milk and dairy products.

In the first place, milk, like meat, contains animal proteins, which on the whole have a definitely higher biological value, *i.e.*, they are used by the body with much less waste than the vegetable and seed proteins. Secondly cow's milk contains a large proportion of valuable salts, particularly calcium and phosphates, which are essential to the growth and maintenance of the skeleton and the proper functioning of the organism generally, and which tend, particularly in the case of calcium, to be definitely below the optimal level in the *average modern dietary. It has been suggested that the* bony resorption which not infrequently occurs in middle age may result from a prolonged dietary shortage of calcium due to the relative neglect of milk and cheese in the diet. It is dietetically extremely difficult to *obtain this calcium in any other way than by milk or* cheese.

I must also mention the astonishing and specific effect of milk on increase of growth and weight that has been shown several times in experiments not only on rats, but also conducted on groups of children under controlled conditions. Finally, I would point our that fresh milk is one of the few animal foodstuffs which we can take, if we wish, before it has either been cooked or subjected to thorough-going processing. This may mean little, or it may mean much. We do not yet know.

Improvement in Quantity

The improvement of the nation's supply of dairy products may be considered from a qualitative and from a quantitative aspect. Let us take the quantitative first.

As regards liquid milk, as is well known we produce more at present than we actually consume, though much less than we ought to consume. The daily intake of liquid milk per person is calculated to be about ⅓ of a pint in this country, whereas in certain other overseas countries which, be it noted, are stated by many to be ahead of us in general physique, the consumption may rise to three times this quantity, or even above. It is also evident that the consumption of milk in this country tends to be higher in towns which, like Bournemouth and Cheltenham, are above the average in purchasing power per inhabitant. It is repeatedly stated by dieticians that 1 pint of milk per person per day should be consumed, either as such or in various forms of prepared food, to ensure a sufficient supply of salts and of proteins of satisfactory amino-acid content.

An increased supply of milk to cover an increased demand even up to this figure could be provided in this country in a relatively short time. To maintain it would require more intensive treatment of pastures, and the cultivation of a considerably greater area of land to provide other food for the cows (unless large amounts of cattle feed were to be imported).

It would also be advantageous to obtain an increase

* Read at the Food Group session, during the Annual General Meeting of the Society in Newcastle, 1933.

… the average yield of milk per cow—which is mainly question of *breeding and management*—up to an …imum figure depending on the type of cow, the …rict, and the management, but at least 700 gallons … annum for the Shorthorn. From the point of view …ncreasing the herd more rapidly, and with less waste, …ence *might also help by devising a method for the* …rol of the sex of the offspring, so that the proportion …bull calves could be limited. The extension of this …owledge to the human might lead to interesting social …anges.

The pertinent question as to how far the modern cow …n be quantitatively improved as a milk factory is a …st interesting one. She already provides four or five …mes as much milk as she would in a normal lactation …riod with a suckling calf. During a lactation period, … *good cow may give in the solids of the milk no less* … n three times her own (solid) weight. It is question…ble whether there is any real purpose to be served in …ndeavouring to push this much farther. The limiting …tor may be either the length and functional capacity … the digestive system, or the *secreting capacity of the* mammary glands, but in any case the law of diminishing returns begins to operate at about 700—800 gal. in …at for every gallon of milk produced beyond this …gure, the quantity of concentrates required by the …erage animal increases steeply, and influences more and more seriously the net cost of production of the extra gallonage.

But the contingency of a rapid increase in the demand for milk is a remote one, almost as remote as the likelihood that I have just mentioned regarding the sex of offspring. In fact, at present it is stated on good authority that the consumption of liquid milk in this country is diminishing. Certainly any readjustment towards an increased consumption would be so gradual as to be almost imperceptible. There is, however, the question of the possible methods by which a reduction of cost per gallon to the farmers might be attained. The health of the animals is of first importance, in order that wastage may be diminished and first-class dairy cows may be maintained in a herd for a considerably greater period than the four years which seem to be the present effective milking life of a dairy cow. The volume of milk produced per lactation rises up to the fifth or sixth lactation. Good management and attention to the laws of health undoubtedly result in a longer average productive life and thus effects a saving to the farmer *in the cost of raising or buying young stock to* replace wastage. A healthy herd not only produces more and better milk, but tends to decrease the replacement expenses which have in any ease to be made a charge on the milk sold by the farmer to the trade. It is questionable whether *the majority of farmers* realize the benefits that might accrue in preserving the health of the herd if fairly frequent visits from a competent veterinary practitioner were the rule rather than the exception. This seems to me to be one of the more important ways *in which science could help to improve* both the quantity and quality of the supply of dairy products. The periodical inspection of all dairy herds by a qualified veterinary inspector is a possible development in the near future.

Although it is, I think, true to say that the average cow is better fed than the average human, as she certainly leads a quieter and more contented life, it is equally true that the last word has not been said about *methods of feeding during lactation. The salt content of* the diet is frequently not sufficiently considered, particularly in view of the enormous demands for Ca and P in the milk during the height of lactation, which demands, if insufficiently supplied by the diet, are supplied by salts withdrawn from the bones, a process in which the results become more disastrous with each succeeding lactation. The quality, *i.e.*, the amino acid composition of the *proteins* in the diet, is another point on which further experimental evidence is required. Nevertheless, nutritional knowledge has been applied very thoroughly to the rationing of dairy cows, and no *farmer in this country need go without* modern information on this subject if he will take the trouble to get in touch with his county agricultural organizer.

From the farmers' point of view, one of the most satisfactory developments which could take place at present would be a steady increase in the demand for liquid milk with the maintenance of a price not too far below the present one. He is nevertheless not seriously interested, apparently, in advertising his products. Science might perhaps help to improve the food supply of the nation by an educational campaign among the people at large, but some of these who should be conducting this campaign are so obsessed with the possible, and in certain cases undoubted, dangers of drinking raw milk that they do not always perceive the much greater danger to the *general health of the nation of a* diminished consumption of it.

Improvement in Quality

It is with regard to quality of milk and of dairy produce that science will probably be of more assistance in the near future. For many years past, emphasis has been on quantity rather than quality owing to the *fact that until recently payment for quality, at least for* milk destined for the liquid milk market, was most unusual, and was therefore, from the point of view of profit to the farmer, a matter of little importance. Where butter or cheese is to be made from the milk, *quality is a matter of first importance, and for many* years in those parts of the world where the manufacture of cream, butter or cheese is the major interest milk has been bought on a quality basis—usually a butterfat-basis.

This is now extending, in this country, into the liquid milk market also, and buyers are frequently finding that their milk is not of the quality desired—not, in some cases, up to the legal requirement of 3% butter fat and 8·5% solids-not-fat. As a consequence, many farmers *having herds which yield poor-quality milk (although* the individual animals may be high yielders) are in a serious position and are requiring immediate assistance.

The occurrence of a milk with low fat and low solids-not-fat content appears to be fairly widespread in this country, even in herds in which the management is, apparently, good. It may be a result of the emphasis laid for many generations of cows on volume production,

or it may be that there is some subtle defect in management or nutrition that has so far escaped detection, or, of course, it may be that for certain breeds the legal *standards are too high*. This latter possibility is unlikely, but there is no question of the increasing *seriousness of the situation*.

There is no method known for improving over long periods the quality of the milk of a given cow. It is true that the fat content of the milk can be diminished by feeding cod-liver oil and other fish oils, but no *method is known for increasing over a reasonable fraction* of the whole lactation period the quantity of either the fat or the solids-not fat in milk of a given cow or herd. It has been suggested that much of this low-quality milk is actually pathological, and not normal milk, but we again meet ignorance here, for it is impossible at present to define satisfactorily what is meant by normal milk.

Science, however, can help the farmer who is up against the practical problem of low fat or low solids-not-fat in his milk by finding for him the worst offenders, by advising the steady elimination from the herd of those cows (and possibly of their progeny) which give the poor milk, and by recommending breeding from animals of a stock known to yield high-quality milk. Science is also helping indirectly by devising new, quicker, and at the same time accurate, methods for determining the quality of the milk. A method recently introduced at Shinfield for the determination of total solids in milk would have saved one of our workers about a year of his working life if it had been devised four years ago.

One of the ways in which science, particularly analytical chemistry, has helped to improve the milk supplies of the country is in the devising of methods to check various forms of illegal processing, *e.g.*, the partial skimming of cream from milk, or the simple addition of water, which was, I understand, an almost traditional procedure in certain parts of the country some years ago—1 gal. of water to 12 or even, if the milk looked rich, to 10 gal. milk.

It has been known for some years that the freezing point of milk is very constant, and approximately the same as that of blood serum. Dilution of the milk with water raises the freezing point and can readily be detected by a sufficiently delicate freezing point determination. It has recently been shown that genuine milk, even if far below the legal limit for fat and solids-not-fat, has the same freezing point as that of normal milk. Thus injustice to the farmer (the presumption is usually made that if the fat and solids-not-fat content of milk is below the legal limits then water has been added) can be avoided and at the same time the public can be defended against fraud by a determination of the freezing point of the suspected milk. If, of course, the producer or dealer dilutes his milk with a salt solution having a freezing point of $-0{\cdot}55^{\circ}$ C., the freezing point method breaks down, but a scientific fraud of this kind is not the average producer or dealers' *forte*.

Another aspect of quality in which science has helped and is helping the farmer to improve the milk supply is in securing the bacterial cleanliness of milk from the beginning and in avoiding contamination later by bacterial control of the processing. No one likes drinking dilute sewage, even after pasteurization, and there is no reason now why any farmer in the country should not be able to produce clean milk of a low bacterial count given goodwill and a certain amount of pertinacity on his part. Two of the essential factors in the production and distribution of milk of a high nutritional value and low bacterial count are the avoidance of contamination at the source, and the rapid cooling as soon as possible after milking to avoid bacterial growth in what is, of course, an excellent culture medium.

In some of the larger dairies in this country a great deal of attention is now being paid to the bacterial cleanliness of the milk on receipt, even if the milk is destined to be pasteurized. The pasteurization of dirty milk, as might be expected, turns out an inferior article, and I believe that the standards required for milk by the bigger dairies would be more exacting if it were not for certain unscrupulous firms who are ready to take "any old kind" of dirty milk, pasteurize it, and undersell the more reputable firms at the ultimate expense of the consumer.

In the processing of milk—in methods of pasteurization, in methods of preparing condensed and dried milk, in methods of avoiding losses due to bacterial and yeast contamination and to taints of various kinds—scientific methods of control have been of particularly great value in bringing safely to market large quantities of high-class products. It has been found, for example, that a rancid or tallowy taste sometimes present in milk, more frequently in products in the making of which milk has been used, is due to the presence of small quantities of a heavy metal, usually copper or iron, in the milk or milk product, quantities of the order which can easily be taken up by milk in passing over a naked copper surface, such, for example, as a worn pipe or cooler. Copper is by far the most active of the metals tried in producing these taints, which are actually due to partial oxidation of some of the fatty acids of the butter fat, a process catalyzed by traces of copper. It has also been found that exposure to air and light increase the susceptibility of butter to autoxidation and its attendant taints.

Still another aspect of milk quality in which science is playing a great part at present is in controlling the vitamin content of the milk. I need not dilate before this group on the necessity for vitamins in any complete diet. It is doubtless owing in part to its vitamin content that milk is such a valuable foodstuff, but it has been found that there are immense variations in the amount of the various vitamins in milk. These are controllable to some extent through the diet. Cows fed on green fodder, for example, have a good deal more vitamin-*A* in their milk than cows fed on a winter diet. One of the lessons arising out of this work is that milk should be consumed without undue delay to obtain the maximum quantities of unchanged vitamins. Incidentally, it has been found very recently at Shinfield that the antirachitic vitamin-*D* of milk is chemically different from that in cod-liver oil, or in irradiated ergosterol. The matter is being further investigated.

Butter and Cheese

I have as yet hardly touched on butter or cheese, though some of the problems which underlie their manufacture have been solved by science, and more are in course of solution. Practice is still rather lagging behind. It is now possible by suitable feeding of the cow to control to some extent the physical characters of the milk fat secreted, and hence the quality and flavour of the butter, and also of the cheese, made from it.

The flavour, particularly the aroma, of butter is due largely to the presence of diacetyl, $CH_3CO{\cdot}CO{\cdot}CH_3$, an oxidation product of acetyl methyl carbinol. The carbinol is a normal metabolic product of a number of bacteria, acting on various sugars, among which bacteria are the lactic acid organisms. Acidity of the cream before churning is essential for this aroma production since sweet cream does not contain the carbinol. However, the oxidation of the carbinol during the storage of butter initiates oxidative changes in the butter fat, and butters of strong aroma have poor keeping qualities. The addition of diacetyl to butter and to margarine to improve the flavour has been described. I am not certain about the ethics of this, but it seems in some ways just as innocent or as depraved as the addition of annatto in the manufacture of cheese. The starters (cultures of lactic acid bacteria) now available for cream ripening are better than those formerly used. By using starters containing the same mixture of organisms in the right proportions the same general flavour and aroma tend to be produced, and a high quality of butter may be attained and maintained. A good deal is known about starters, but this knowledge is used in practice perhaps more overseas, in Denmark and New Zealand, than at home. Starters, of course, play a great part in the flavour and quality of cheese also. It is interesting to note that many of the faults in cheese may be traced to the presence of contaminating bacteria from the poor quality milk used, and that an improvement in the cleanliness of the milk supply would eliminate such faults. Knowledge of methods of producing clean milk is widespread in this country, though again not always put into practice. Much information is also now available as to the best conditions for ripening cheese and for maintaining a steady quality throughout the year.

One of the most serious problems facing the cheese industry to-day is the profitable disposal of whey. Whereas on the farm, much of the whey can be used for the feeding of pigs and other stock, in a cheese factory disposal by this means is difficult. However, very efficient methods for whey drying are now extant, and if a reasonable fraction of the available whey could be dried, an easily transportable and very valuable foodstuff could be made available in large quantities. The amount of whey thrown away is estimated at between 10 and 40 million gallons per year. This is rather disturbing when one realizes that about one-half of the food value of the original milk is lost in this way. Methods of disposal of whey are urgently required. I understand that dried whey could be sold at 2½d. to 2¾d. per lb. In view of its high food value, this must be one of the very cheapest foods on the market and science ought to be able to find methods for the utilization of this valuable material.

The Present Emphasis

Looking at the question of the improvement of the nation's food supply from the long distance standpoint, it seems to me that as far as dairy products are concerned, two things should receive major emphasis now and in the immediate future. They are first, the dissemination to the people at large, perhaps in the first instance to medical men, to teachers, and later to all other intelligent people, of sound, scientifically accurate information on nutritional principles and dietary requirements. Most of the main mass of information is readily available to them, and much present-day nutritional research is merely crossing the t's and dotting the i's of the script already written. Increased consumption of milk is to a great extent an educational and not a strictly scientific problem. Secondly, we are in a much less happy position with regard to the fundamental problems of the physiology of milk production—how the complex mixture of foods that the cow ingests is transformed so rapidly into the white fluid called milk—and we do not yet know enough about the chemical and physical characteristics of this strangely unstable system. These problems, it seems to me, should be tackled with assiduity, and together with scientific data of the highest importance much valuable practical information will undoubtedly emerge.

To sum up in a sentence or two the gist of my argument: (1) We have the scientific knowledge to-day to enable us to produce, efficiently and satisfactorily, all the liquid milk required at present for the nation's limited consumption, and it would not be difficult to expand this production, given reasonable time, to meet the considerably larger requirement of at least 1 pint per person per day that is considered in the highest degree desirable by all informed students of nutrition. (2) We have most of the scientific information we require for the production of high quality butter and cheese, and by adequate intensity of farming it should be quite possible to produce at home a much greater part of our nation's annual consumption. Whether this is advisable or not is another matter. The trade of New Zealand and of Denmark, with which countries we have many ties of friendship, would be ruined by such a procedure. Moreover, they cannot buy from us if we do not buy from them.

May I conclude by the categorical statement that if the nation's dietetic status is to increase, and its health to improve so that it shall have real abounding health, and not the mere absence of the more obvious symptoms of disease, it must drink more milk and consume larger quantities of dairy products? It is mainly the poverty and dietetic ignorance of the would-be consumer and not lack of scientific knowledge which is at present the limiting factor in the improvement of the food intake of the nation. As far as dairy products are concerned the improvement of the nation's food supply is now more immediately a question for economic, social and educational, than for agricultural, science.

DISCUSSION

Dr L. H. Lampitt, discussing increased yields of milk, emphasized the necessity for educating the farmers before any material advance could be made, for it was sometimes difficult to get the farmer to effect improvements. He knew of one case in the West country where certain breeding stock bulls were introduced whose progeny might be expected to yield increased quantities of milk. After a little while however, the farmers did not take the trouble to utilize them, and they seemed to be content with a yield of about half the 700 gallons per annum mentioned in the paper.

Mr. Gabriel Jones, commenting upon Dr. Kay's reference to the application of the freezing point test to milk and the fact that if a farmer diluted his milk with a salt solution having a freezing point −0·55° C., the freezing point method would break down, said that no public analyst of any repute would confine himself to the freezing point test but would determine the amount of chloride in the ash. Another matter on which he joined issue with Dr. Kay was the reference in the paper to the legal requirement; the legal requirement for milk was milk as it came from the cow, no matter what its composition, so that in effect there was no legal requirement.

This nation required a great deal of education in regard to food. Too many people were misled by glowing advertisements, and were replacing the good simple foods of our forefathers by foods which they bought by reason of the colour of the labels under which they were sold or the statements made in advertisements concerning them. While this made for convenience there was waste of money, particularly on the part of housewives who could not afford to waste it.

In urging the elimination of the small milk dealer, Mr. Jones said that although he did not advocate nationalization or municipalization of many things, he did feel that it should not be permissible for anyone to buy a few cows, keep them in a back street of a town, with the minimum sanitary arrangements, and supply milk from those cows. In many cases no precautions were taken as to cleanliness; gross dirt was hidden or rendered invisible by straining, but one knew how much went into solution. It would also be a good thing, both from the point of view of the farmers and of the health of the population, if the importation of condensed machine-skimmed milk could be stopped. Enormous quantities were consumed in this country and he believed that some of these products came from countries in which their use was prohibited.

Prof. H. E. Armstrong, F.R.S., urged that this discussion should be devoted to bringing the facts home to the public and that not a minute should be devoted to the discussion of scientific details, for it was the education of the public on these matters that was so badly needed. A few days ago he had been looking at Disraeli's first novel, "Vivian Grey," which was written in 1826. On the opening page reference was made to Vivian being sent to a preparatory school; the charges were stated to be 100 guineas per annum, and it was added that there were no extras except for fencing, pure milk, and the guitar. Pnre milk, he commented, remained an extra to-day, not only in the schools but in the homes of the country, and that state of affairs was a disgrace to our scientific civilization. We must raise the intelligence of the nation in this particular. That the original standard of milk should prevail up to the present was an absolute disgrace to our science, because we knew that the standard was the lowest quality milk that a cow could produce. He would change the curriculum of medical men and make their early training of some value, teaching them to think in scientific terms. It was to the disgrace of the medical profession of this country to-day that not only did it not advocate the use of milk but that it was taking the opposite course; medical men were definitely discouraging the use of what we knew to be the most important of all foods, and until we could rid ourselves of that disgrace, until the profession could become an intelligent profession in that respect, there was no help for us.

Then how were we to increase the intelligenee of the public? Could the teachers in the schools be made intelligent to the extent of teaching anything about it? He doubted it. He had been trying to develop methods to teach people to think a little for themselves, but had come to the conclusion that on the average it was impossible. He was beginning to believe that we should follow the Church, which had at its command—although it had lost its place—a set of ten commandments which were taught to all. We should have a set of ten commandments connected with milk, and if the outcome of this meeting were to appoint a committee to draw up those commandments it would render a service beyond compare. We could do nothing except by being dogmatic and setting a fashion. Women would follow a fashion but would *not follow intelligence*; men also were afraid to do something fresh—they would not even wear a coloured waistcoat!

Prof. Armstrong suggested that Dr. Lampitt had struck a false note when he had advocated taking steps to increase the yield of milk from the cow. Probably the obtaining of large yields of milk from the cow was at the root of our difficulties in connexion with tubercular disease: it could not continue to produce the enormous quantities that it was asked to produce and remain healthy. We were coming to the conclusion more and more that our one chance of getting rid of this disease was in the first place to improve the health of the cow so that it would yield milk of real value. There was an enormous amount of evidence showing that animals fed on a proper diet were practically immune from that infection. One could not say yet what were the causes of some diseases such as cancer, but one could not help feeling that the great changes in our methods of feeding ourselves might render us sensitive to attack. He referred to some experiments carried out in which two sets of boys were given a glass of milk a day, one set having milk from cows fed on the ordinary winter ration, and the other on milk from cows fed on summer-cut dried grass, which latter was of superior value as food. There seemed to be some evidence that the boys fed on this special milk were in better health than the others.

Mr. W. H. Cadman, enlarging upon Dr. Kay's point that there was a good deal more vitamin-*A* in milk

in cows fed on green fodder than in that from cows on a winter diet, said that the drying of grass green was technically possible, but for large scale operation at present it was uneconomic. It did not follow however, that it need remain an uneconomic proposition, and he urged upon industrial chemists that one of the outstanding problems connected with this subject was to devise a simple drying process whereby grass, when only 9 or 10 inches high, could be dried quickly in the green state so that it retained its valuable vitamin constituents, and could be given to the cow in that condition as winter fodder. In Sweden it had been converted mostly into a meal because of the high market value of that product; and in this country a few attempts had been made, with very promising and definite results, as regards the effect upon the cow. Not only was the cow in better health throughout the winter than was the case formerly, but the milk it produced was of a quality similar to that obtained in summer, when the cows were grazing in the fields. If such a scheme could be carried out on a large scale throughout the country, we should not need to import enormous quantities of concentrated feeding stuffs, such as cotton-seed cake, linseed cake, soya bean cake, and so on; the cow fed on this dried fodder obtained sufficient nourishment to enable it to produce an adequate quantity of milk, without the necessity for concentrated foods.

Mr. Cadman asked Dr. Kay if there were proof that consumption could be transmitted through milk from tuberculous cows. He had a small herd of pedigree Jersey cows for his own purpose, and they were regularly tested for tubercular disease. Wishing to increase the amount of milk available, he had bought a milk-recorded Shorthorn cow and had it tested by a veterinary surgeon. To all appearance there was no clinical evidence of tuberculosis but the Shorthorn reacted exceedingly badly to the tuberculin test, and the vet. advised that that cow should not be put with the Jersey cows, in view of the risk of their contracting the disease. Our county agricultural organizations paid a great deal of attention to milk-recorded cows, and were aiming at increased yields, but no attention was paid to the question of cows being reactors to the tuberculin test. Either the test was of value or it was not. If not, then the statements made about Grade-A milk, which was sold at an increased price, were valueless. In herds where the tuberculin test was applied and where Grade-A milk was obtained, the non-reactors were kept apart for supplying that Grade-A milk, and reactors were put into the main herd to provide the general supply of milk. Consequently, we had the anomalous position that the public who were buying milk other than Grade-A from the large producers were buying milk from a herd the overwhelming majority of which were actual reactors to the tuberculin test. If there was anything in the tuberculin test, then that practice should not be allowed. Unfortunately, with the exception of the small herds of tuberculin-tested cows, from 75% to 90% of the dairy cows of this country were reactors to the tuberculin test. Dealing further with this question as to whether or not the tuberculin test was of value, he recalled a lecture in which it had been stated that cows crossing the border from Germany to France had to be subjected to the tuberculin test. The dealers had engaged, at a high fee, a very skilled veterinary surgeon, because so many cows were reactors and were not allowed to pass. This man had accepted the task, and had taught the dealers that if they carried out the test within 24 hours before reaching the border, the cows were in such a condition that when a second test was made in the normal way at the border, they would not react. For quite a considerable time cows which were reactors were passing over the border by reason of that trick. It might be necessary therefore, for chemists to devise tests to defeat the efforts of unscrupulous dealers who used science to defeat the real objects of science.

Expressing agreement that it should be possible to eliminate small herds in the neighbourhoods of towns and villages, which were kept under insanitary conditions, he suggested that frequently, if their milk was tested bacteriologically and if the milk pails and cans were examined, they would have to be condemned.

Dr. H. E. Cox suggested that one method of improving milk would be by reducing the amount of water in it — he did not mean, of course, added water. If the minimum standard of total solids (11·5%) were increased to 13·5%, we should thereby increase the amount of milk solids by about 18%. We should then get in milk more of the salts we needed to make bone and the proteins we needed to make flesh. Water also found its place in cream and it ought to be cut down; there was competition between cream of 45% fat and of 20% fat. Cheese was processed with further additions of water; salts were put in, but not the salts we required to make bone. Water should be cut down in all these things, and then if we needed more liquid it was a matter for competition between the brewer and the water board!

Dealing with the references to the presence of diacetyl producing flavour in butter, he asked what was the real evidence of the presence of diacetyl in natural butter, because he had tested many samples but had never found it. It was frequently added however, and if it were to be added we ought to know more about it and its effect on enzyme action and nutrition generally. In his submission it was not natural in butter, and if that were so, he suggested that its use ought to be stopped.

Dr. Kay, replying to Dr. Lampitt's remarks, said that very careful management and feeding were necessary if one were to get 700 gallons of milk per annum from a cow, and he imagined that unless there were good bulls in the neighbourhood and steps were taken to educate the farmer and show him how to feed in order to produce the 700 gallons per annum, the attempt would be disastrous. Further, it was of no use asking the farmer to produce more if he could get only 4½d. per gallon for his milk.

Replying to Mr. Gabriel Jones, Dr. Kay said he had not suggested that the freezing point test should be the sole test; a competent analyst would not stick to one determination if there were any doubt whether or not milk had been adulterated. Although there was no legal standard technically, if the fat content were 3% and the solids-not-fat were less than 8·5% it was assumed the milk had been adulterated. The "legal" standard was the effective one and not a technical legal standard.

After agreeing with the remarks made concerning the small producers, Dr. Kay pointed out to Prof. Armstrong that the orange book, recently published, containing the report of the Griggs Committee, emphasized in several places the importance of official control of the standards of milk. He was sorry to say that that had to some extent been shelved by the red book of the National Farmers' Union which was at present before the Government. Information of the management necessary in order to produce large quantities of milk from a cow was available, but was not very well disseminated among farmers.

The conveyance of tubercular infection from animals to humans was a problem about which we did not know as much as we ought to know.

With regard to the storing of grass in more or less unaltered form some experiments recently conducted seemed to give a lead in a direction which might prove fruitful, in that it was found that if short grass were piled and treated with dry whey plus water, or with whey not dried, a fermentation ensued which preserved the grass in a very pleasant form with apparently very little change in colour, and as far as one could make out with very little change in its nutritional value. The point had not yet been established authoritatively.

The problem of the disposal of reactors to the tuberculin test was admittedly difficult, a difficulty being how to tackle the problem in order not to upset the market for cattle in the country. The percentage of reactors among dairy herds was extremely high, though perhaps Mr. Cadman's figure of 75% was rather too high. If any faking of the tuberculin test were found to occur, the matter should be reported to the Ministry of Agriculture, and he believed it would be taken up.

The increase of total solids in milk to 13·5% could only be accomplished by suitable breeding.

Finally, with regard to diacetyl in butter, he had not the reference with him—though he would be delighted to obtain it for Dr. Cox—but he believed there was very little doubt that diacetyl was present in normal butter, produced by the action of lactic acid organisms on lactose. It could be detected by distillation and separation of the nickel glyoxime compound, and could be estimated by determining the amount of nickel.

HOW SCIENCE CAN HELP TO IMPROVE THE NATION'S FOOD SUPPLY—WHEAT*

By E. A. FISHER, M.A., D.Sc.†

The miller's requirements in the matter of wheat quality are widely different from those which for many years have satisfied the grower of wheat in this country, except in so far as cleanliness and good appearance of the grain are concerned. The grower's main consideration has been yield per acre. The miller is not concerned at all with yield, but demands good milling and baking qualities. These points of view are not opposed still less are they irreconcilable; but they are different and have little in common. With one notable exception, to be referred to later, the agricultural organization of this country has shown, for more than half a century, an almost complete indifference to the requirements of wheat buyers, to the needs of the milling industry, to the question of wheat quality as distinct from quantity. It is unfortunate that the farming community should have so little knowledge of the quality differences of home-grown and foreign-grown wheats. The quality of English wheat has been the Cinderella of agricultural research. The relation of all kinds of factors to yield of wheat has been studied, but quality hardly at all. Many farmers and others are still prepared to believe that a good sample of all-English flour will make as good a loaf as No. 1 Manitoba. And yet from a breadmaking point of view these two flours are at almost the extreme ends of the scale. Certainly there is no finer flour in the world than No. 1 Manitoba and there can be few poorer than some varieties of English wheat.

Biffen's brilliant effort in producing the Yeoman wheats is the exception which proves the rule: the Cambridge investigations stand quite alone in this country and were possible only because the quality investigations necessary to success were carried out by and at the expense of a private milling firm. The idea that wheat has quality at all, or that quality is something different from yield and plumpness and soundness of grain, is not appreciated by farmers. The reason may be that wheat is not grown with any definite object—apart from the straw: perhaps it is not grown as a crop, but as a by-product which may find a use somewhere, if not among millers then among poultry farmers. In America, which is at least as highly industrialized as England and where, as in this country, agriculture is still the biggest industry, most of the flour milling research is done by the agricultural colleges and departments: wheat is grown with a purpose and the question of quality is to the fore in all teaching, research, and advisory work in connexion with crops.

The reason for this apathy and singular ignorance of wheat quality is to be found in the history of wheat growing and of the milling industry during the last 60 years.

In the 'fifties of last century wheat was grown in this country which suited the demands of the milling industry and English wheat formed an important part of all breadmaking grists. Even at this time we were very far from being self-supporting in the matter of wheat. In 1854 one mill in the west of England did not use more than 15% of English wheat in the mixture. Large imports of wheat came from abroad, mainly from Russia, Hungary and other eastern European countries. These imports, however, were not in competition with English wheat, but supplementary to it. It is estimated that there were 10,000 small mills, all of course milling on stones, scattered throughout England and Wales. Transport charges then, as now, were high and so acted as a tariff on imported wheat, the home-grown crop being milled at the local mills in the districts where grown. The standard of quality was different then. In fact, it was not really known what quality meant; there was no outside or independent standard

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which to judge the quality of our wheat. Strength was less important then than now. Home baking was general. Fermentation was carried out with brewers' yeasts and barms and the baking processes were easy or comparatively gentle and suitable for the soft flours which were at that time almost the only ones available. This was the situation up to 1874 when the prosperity of English farming reached its peak. Later came the decline, the year 1879 in particular being still referred to as *the* example of what a bad year can be. It is, however, not generally realized to what a great extent agricultural depression in this country was hastened by the technical revolutions which occurred elsewhere, *i.e., the rapid development of the virgin wheat lands of* North America, and the substitution of roller milling for stone milling which took place first in Hungary and spread to America in the '70's of last century. One immediate result of these changes was the importation of American flour, milled by the new roller process in America from hard American wheats. This set up an entirely new standard of flour quality and changed the nature of the demand for bread. The problem of dealing *with this changed demand fell to the English miller* who to compete with the Hungarian and American miller and the flour importer was compelled to change his methods and to adopt the new roller process. The capacity of rollers is greater than that of stones; many small mills disappeared, others increased in size, and many amalgamations occurred. New and larger buildings were necessary to house the larger plants and the demand for the harder Hungarian, Russian, and particularly American wheats increased. Transport charges in this country were high and the new mills were transferred to the ports, thus in large part transferring the heavy transport charges from the foreign to the home-grown wheats. The disappearance of the rural milling population proceeded rapidly and with it the decline in wheat growing. The decline was hastened by the farmer's response to these changes: *he concentrated on yield at the expense of* quality and began to grow inferior varieties of high cropping power. And this at a time when the standards and requirements of the flour trade had changed radically. Stronger, higher quality flours were essential to meet the changes in public taste. The home baking and brewers' barm of earlier days had given place to commercial baking and distillers' yeast. Stronger flours were required to stand up to the longer and more drastic baking processes and the flour of superfine quality imported from overseas opened the nation's eyes and imposed a new and higher standard of bread quality. In such circumstances the small country miller was placed at a serious disadvantage in competition with the large merchant mills at the ports. As the latter prospered the small country miller slowly but steadily disappeared and with him went the farmer's hope of profitably marketing home-grown wheat for breadmaking. *The fate of the English wheat grower has been* closely bound up with that of the country miller. If this had been realized 60 years ago and the farmer instead of concentrating on yield had concentrated on quality, working in co-operation with his colleague the country miller, much might have been done to maintain a nationally more satisfying equilibrium between the port and country sections of the milling industry. Of course, nothing could have prevented the migration to the ports: *the fact that 80% of our wheat requirements comes from* abroad is the determining factor in making our milling trade essentially a port industry. But had as much attention been paid in the past to the quality of the home-grown crop as was paid to yield a much larger number of country millers would have maintained a secure position in the industry to the permanent advantage of the wheat grower. For this end to be gained it would be necessary for the wheat to be grown, ground, and consumed locally, *thereby relieving the miller of the heavy* transport charges on foreign wheats from the ports. Higher quality wheats were necessary for this purpose and they were not forthcoming until it was too late.

The magnitude of the change is indicated by the following approximate figures: the estimated 10,000 small mills of last century have been replaced by 600 or 700 larger ones and more than 90% of the wheat milled in this country is milled by 300 concerns. More than half the wheat milled is milled in the four port areas of London, Hull, Liverpool with Birkenhead, and Bristol with Cardiff.

This degeneration of English wheat reached bottom by about 1890 and in that year, and again in 1900, appeals were made by the milling industry to all the agricultural interests in the country with a view to improving the quality of the home-grown crop. These appeals met with no response and the milling industry in consequence in 1901 set up its own Home Grown Wheat Committee, which will always be associated with the name of A. E. (now Sir Albert) Humphries, to study the problem. This Committee was fortunate from the start in gaining the interest of the Cambridge School of Agriculture, of Rothamsted and of Wye Agricultural College. In the quarter century that followed an immense amount of collaborative work was done under the auspices of the Committee—the biological and chemical work at Cambridge under R. H. Biffen and T. B. Wood and milling and baking investigations at Weybridge under A. E. Humphries.

This group of workers, which for brevity may be called the Home Grown Wheat Committee, set before themselves three objects: (1) to define wheat quality or strength; *i.e.*, what qualities are really desired in a baking flour; (2) to find the underlying causes of good baking quality; (3) to harness good baking quality to English varieties by breeding.

Of these three objects only one, the third, resulted in any considerable measure of success. The two fine wheats, Yeoman and Yeoman II, have been a great asset to English wheat growers in many parts of the country. Their development was a magnificent achievement, intellectually though not economically comparable with that of Marquess wheat in North America. The achievement was the more striking on account of its essentially empirical basis on the chemical side. I say "empirical" advisedly for we still know nothing concerning the causes or essential nature of good quality and only of very recent years have we begun to acquire a clear idea of the qualities really desirable in a baking flour. If it has been possible in the past to harness reasonably good quality (concerning the nature of which

we know so little) and good cropping power in the Yeoman wheats, what may not be possible in the future when the underlying causes of and factors in high quality are more clearly understood? In helping the nation to improve its home-grown wheat supply, it is improvement in quality which should be the scientists' first consideration.

Quality and yield are the prime considerations, and the problem of yield (which in its wider sense includes such further problems as disease resistance, strength of straw, etc.) has very largely been solved. Indeed, in some respects the British wheat grower does not realise his own good fortune. Biffen and Engledow wrote: "The one outstanding and encouraging fact, which strangely enough always seems to be ignored, is that England is in some important respects extraordinarily well suited for wheat cultivation Indeed taking everything into consideration it is probably the best country in the world from the wheat producers' point of view, and, as over-production throughout the world gradually ceases, wheat-growing must inevitably come into its own." Much has happened in the wheat fields and wheat markets of the world since 1926 when these words were written; but they remain essentially true. Our climate, though not conducive to the production of strong wheats certainly favours high yields. The crop is almost entirely autumn sown and the longer the crop is in the ground the greater is the output of grain. Quite apart from time of sowing, the varieties developed in this country are all high yielders: Square Head's Master and Rivet, for example, are probably the heaviest croppers known The great wheat-growing countries which are important as exporters in the international wheat markets—Canada, Argentina, Australia, U.S.A., and at times India and Russia—grow entirely or predominantly spring wheats which are inherently poorer yielders than winter wheats.

Drought and frost which take such a heavy toll in many other wheat-growing countries are negligible factors in England. It is true that rain sometimes causes trouble prior to sowing and at harvest and, more frequently, more serious trouble to quality through sprouting of the grain, but in the aggregate it has little effect on the yield.

Another favourable circumstance, which is somewhat surprising in view of the general dampness of our climate, is the general healthiness of our crops. Compared with the devastation wrought in some countries, Argentina for example, by the various rusts fungoid diseases of cereals are only a minor trouble to the English farmer. The soil too is favourable to wheat: the typical wheat land of Lincolnshire, for example, is probably as good as any in the world.

The following figures for yield given by Biffen and Engledow are instructive. In the early middle ages the average output per acre was about 10 bushels. This increased slowly to 11·2 bushels in 1699, to 23 bushels in 1770, and to 30—32 bushels in 1883. Since 1883 the average yield has shown no marked increase. The steady increase up to 1883 was due to two groups of factors: improved agricultural practice in the matter of drainage, cultivation, manuring, etc. and the introducrion of new varieties of higher cropping power.

During the past 50 years science has done little in increasing yield. It must be remembered, however, tha the natural advantages referred to above possessed b this country render the problem more difficult and les urgent than in most other wheat-growing countries There are fewer and less serious cereal diseases to combat less drought and frost to fight. Nevertheless, greatl improved quality has been harnessed to good croppin power in the Yeoman wheats—a notable achievement.

A very great deal could be done by the farmin industry itself in utilizing existing scientific knowledg and experience in order to increase yield. To quo Biffen and Engledow again: "The demand (for highe yields) comes in the main from those who only produc average crops, and it is rarely mentioned by those wh normally grow 48 bushels or more per acre. A fa larger yield than the average 32 bushels is clearly possibl with existing forms of wheat if the grower will but se himself the task of producing it. The demand is reall for new wheats which cannot help cropping howeve much the grower leaves undone. . . . A 10% increas under such conditions is within the bounds of possibility and a percentage one declines to anticipate if bette cultivation goes hand in hand with new wheats bred f their suitability for more intensive cultivation than general nowadays."

For purely economic reasons wheat for many yea has played a diminishing part in English agricultur until to-day it represents only 4% of the total value the agricultural produce of the country. The ar under wheat, under the stimulus of the war, rose fro 1·87 million acres in 1914, to 2·64 million acres in 191 Since then it has steadily declined until in 1931 only 1· million acres, less than half the acreage of 1918, w under wheat. Total production has fallen from ov 75,000,000 bushels in 1921 to under 38,000,000 bushe in 1931. It would appear that the cropping proble needs no further help from science in the immedia future. The acreage could be doubled without exceedi that of 1918 and possibly a 50% increase in yield cou be attained by a systematic utilization, on a nation scale, of existing knowledge and experience. In oth words the existing output of wheat could be increas three-fold.

This brings us right up against the question of qualit It has been estimated that the percentage of the tot wheat consumption of the mills of this country rep sented by English wheat was only 9%[1] in 1930. 1925 it was 16%.[1] Apart from the war years it doubtful whether it has ever reached 20% in the prese century. It is also doubtful whether more than t percentage of existing English wheat varieties cou be absorbed by the English milling industry witho producing marked deterioration in the character of t flour and bread demanded by the public taste.

If the output of wheat from the fields of England in the national interest, to be maintained at a le notably in excess of that of 1918 there appear to three, and only three, alternatives. Either (1) t public must be educated to like a different kind bread and the baker must be persuaded to prefer t handling of a different kind of dough from those comm

[1]. These figures include the English wheat milled alone biscuit flour which is fairly constant in amount.

›-day, or (2) they must be compelled to accept the hanges by the exclusion of foreign flour and the strict mitation of imports of foreign wheats as has been one in certain other countries (France and Germany, r instance, where *the percentage of home-grown wheat* the grists is maintained compulsorily at 90 to 97%), r (3) the quality of our English wheats must be improved. ne Yeoman wheats are not suitable for all soils or all stricts. It is necessary to produce wheats of high ropping power and in quality as good as, or better an, Yeoman suitable for all the wheat-growing areas f the country. The wheats must be good enough to roduce, without admixture or with only slight admixture of foreign wheats, doughs of high water absorption and of handling character satisfactory to the baker nd bread comparable with that made from our present ixed grists.

The first two alternatives seem unlikely to be adopted. We are left the third, which, if one may judge from the story of wheat growing and wheat research in this ountry, may appear to be as unlikely of adoption as ther of the first two. The difficulties in the way are ot, however, as great as those inherent in the other ternatives. It should not be impossible to organize nd carry out an extensive and intensive study on a ational scale of the quality problem in its relation to nglish wheat with a view to producing high quality heats suitable for the different districts and such that e wheats can be grown, ground, and consumed locally ereby avoiding the heavy transport charges characteric *of this country. It is in this direction that science* an be of most use in helping the nation to produce ore and better wheat. Moreover, we have a much earer idea now than we had thirty years ago as to hat is required although we are as far as ever om an understanding of the underlying causes of quality.

It seems appropriate to indicate here what it is we xpect in a so-called strong flour or flour of high quality. e are concerned here solely with that aspect of quality, nown as strength, which is bound up with the chaacter of the gluten. The early work of the Home rown Wheat Committee was made more difficult the apparently conflicting definitions of strength revalent at that time. In 1905 A. E. Humphries, in a eport on the *Improvement of English Wheat*, wrote: It is highly desirable to define strength, or at any ate to say with precision what we mean by the term. seems to me that many differences of opinion are due o the fact that we do not all refer to the same characteristics when we speak of strength. Some investigators, deservedly of good repute, base their stimate of strength on the quantity of water a flour ill absorb to produce a dough of standard consistency. thers take as their standard of strength the quantity bread which can be produced from a given quantity flour. A third view . . . is that strength is to be judged the way a flour behaves in the dough, its toughness, asticity, freedom from stickiness, in other words, by the cility with which large masses of dough can be handled the bakehouse. A fourth view is that strength ould be defined as a flour's capacity to make big, wellled loaves." This fourth view was accepted by the ommittee and has been accepted by many workers since as the real definition of strength. It is, however, a partial definition only and is not really adequate. Quality is a relative term; there is no such thing as good baking quality in any absolute sense. Quality must be judged from the point of view of the use to which the flour is to be put and the method of use. Confining our attention, as we are in this paper, to bread-making flours, one has to consider that it happens not infrequently that the same flour will be treated in a number of bakeries in a variety of ways; *e.g.*, cottage, tinned, and cob loaves may be made from the same flour by baking systems of various degrees of severity employing different temperatures and percentages of yeast. A flour of good quality must be able to "stand up" to a variety of treatments, and high quality becomes in Humphries' words "the sum of excellence on several points." The four definitions quoted above are partial definitions, each defines a different character and all are represented in a really strong flour such as is typified by high grade Manitoba.

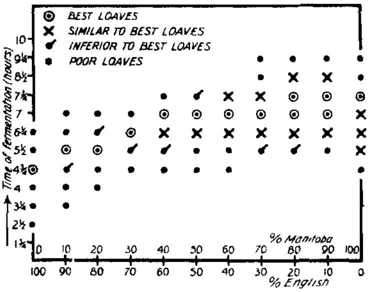


FIG. 1 *Baking quality of Manitoba–English blends*

The differences between a typical strong and a typical weak flour, from the point of view of the bread, are indicated diagrammatically in Fig. 1, which summarizes the results of an extended examination of a No. 1 Manitoba flour, an ordinary English non-Yeoman flour, and blends of these containing from 10% to 90% of English flour. Eleven sets of tinned loaves were made corresponding to the nine blends, the all-English and the all-Manitoba—62 loaves in all. One per cent. of yeast and a fermentation temperature of 80° F. were employed. In each series doughs were made at ¾-hour intervals so that all went to the oven together. The all-Manitoba loaves were incomparably better than the all-English loaves and loaf quality improved progressively in the blends with increasing content of Manitoba flour. A study of Fig. 1 will bring out the following points:

1. The best Manitoba loaf was "thrown" at 7¾ hours and the best English at 4½ hours. Manitoba flour requires a much longer fermentation than English to produce its best bread. With increasing content of Manitoba in the blend the time at which the best loaf was "thrown" also increased.

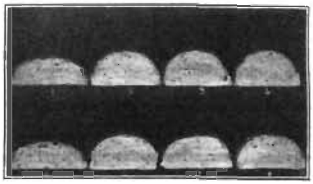
2. There was only one best English loaf, the loaf

immediately preceding and following the best being markedly inferior. There were three other all-Manitoba loaves closely similar to the best. The *fermentation tolerance* or spread of Manitoba flour greatly exceeds that of the English. That is, bread closely similar to the best Manitoba was made with this flour over a period of 2¼ hours, whereas the best English was confined to a period of perhaps half-an-hour. Obviously a flour with a wide fermentation tolerance will "stand up" better to a variety of treatments than would a weak flour of restricted tolerance.

3. The fermentation tolerance increased with increasing content of Manitoba, slowly at first, then more rapidly. Up to 30% Manitoba only one "best" loaf was thrown, the difference in quality between the best and the next best loaves diminishing with increasing Manitoba content. The 40% and 50% blends threw two good loaves each, the 60% and 70% blends three each, and the 80% to 100% flours four good loaves each. A strong flour which produces good bread over a long period is obviously more fool-proof, requires less care and attention during fermentation, is less likely to go wrong in the event of accident or inadvertence, and is consequently worth more to the baker than a weaker flour. The strong flour also gives the larger better-risen loaf because the gluten network is better able to hold the gas liberated during the final stage of fermentation and expanded during the first few minutes in the oven. The outside appearance of the loaf is altogether more handsome and the loaf more saleable in consequence. Its crumb is much better developed: it is softer, more elastic, has greater power of recovery if "thumbed" and its grain, or vesiculation of the crumb, is more attractive. In short, it is more appetising.

It must be remembered, too, that the miller's customer is the baker, not the "man in the street" or bread consumer. The dough must have satisfactory handling properties and typical English flour is deficient in this respect. A strong flour is differentiated in the bakehouse from one which is weak in a way which is difficult to communicate adequately in words to those unfamiliar with baking practice. In the first place the former absorbs and holds more water when the dough is made, a difference which persists throughout the baking process to the finished bread. In other words, it yields more loaves per sack. It gives a dough which has superior handling properties in every respect. This is a very important aspect of strength and one which is frequently not sufficiently stressed. A strong flour gives a dough which is of better "body," tougher, more elastic, and more stable than a weak one. Stability is a most important dough character and one in which English flours—even Yeoman—are particularly deficient. It is the ability of dough to stand up under its own weight and not tend to flow about the table like porridge. It is particularly important in England where a good deal of bread is still made without tins to support the doughs—such as cottages, cobs, and coburgs.

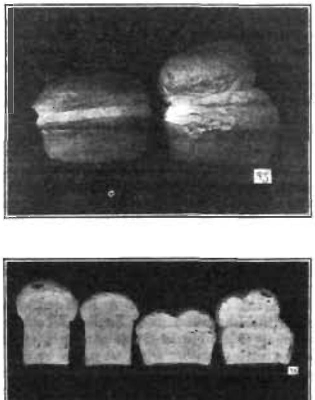
Ordinary English and No. 1 Manitoba flours are at opposite ends of the scale of flour quality. The Yeomans are well up the scale although still nearer the bottom than the top. In particular, Yeoman II has higher water absorption than ordinary English and gives a dough which, though not tough and rubbery to anything like the extent characteristic of strong foreign varieties, is nevertheless of quite satisfactory handling properties. It has appreciably greater fermentation time and tolerance than ordinary English. The bread again is very different: though quite distinct from the product of, say, No. 1 Manitoba wheat, it is not as a rule greatly



1 and 5 Untreated controls
2, 3, 4 Agene, different doses
6, 7 and 8 Chlorine, different doses

FIG. 2.

Effect of agene and of chlorine on flour (15%, bottom divide)



(A)

(B)

FIG. 3.

Effect of agene (heavy dose) on a low grade flour, same sample in A and B

inferior to and is sometimes equal to that baked from mixtures of wheats which constitute a miller's ordinary grists. That is to say, Yeoman flour baked alone without admixture with other flours will yield satisfactory bread suitable for sale when baked in tins. Its weakest feature is dough stability: the dough tends to flatten or spread during fermentation, a defect which it shares with ordinary English varieties, although

to a less extent, in consequence of which it does not as a rule make satisfactory cottage loaves.

Marked improvement in quality can be brought about in three ways: by breeding new varieties (*a*) of higher protein or gluten content and (*b*) of better gluten quality, and by subjecting the flour at certain stages of manufacture to certain well-known treatment processes.

The gluten content of hard foreign wheats ranges round *about* 10—14%, *that of English varieties about* [illegible]—8%. Yeoman is not superior to other English wheats in gluten content, but only in gluten quality. More of a good thing is desirable in this case. Moreover, the higher the gluten content the more responsive is a flour to methods of treatment: so a higher protein content is desirable in English wheats for two reasons.

Chemical improvers have been used for many years in England and in other countries, and there is no doubt as to the improvement in gluten quality which has resulted from the judicious use of some if not all of these materials. One in wide use at the present time is known as Agene, the active principle of which is nitrogen *trichloride*. It is used *in amounts varying from* 1 *to* 20 gm. per sack (280 lb.) according to the grade of the flour. What can be done by Agene in certain cases is shown in Figs. 2 and 3.

Of recent years much has been done, particularly in this country, in developing physical methods of flour improvement with a view to obviating the use of chemical treatment. Physical methods of flour treatment—or *flour conditioning processes* as the writer prefers to call them—based on the use of heat were first developed by Robert Hutchinson, of Nottingham, who patented two such processes in 1921 and 1924. Developments and improvements were brought out by D. W. Kent-Jones, C. W. Chitty, and Woodlands, Ltd., in a series of patents between 1925 and 1930. A rather different form of process, based on the treatment of flour with hot damp air, was developed by the writer and C. R. Jones in 1927. Flour is flung into a cloud by falling on to a rotating turntable and the cloud is blown into a cyclone dust collector by a stream of hot air of nearly 100% relative humidity. The treated flour is precipitated in the cyclone and the air is re-circulated over the heaters and sprays. The treatment is of very short duration (a few seconds at most). Illustrations of its effects on certain flour divides are shown in Figs. 4 and 5. *There is some evidence which suggests that soft* English flour if its protein content could be increased materially would be very responsive to this form of treatment.

There is one further aspect of the home-grown wheat problem which deserves, and has recently been receiving, attention, viz., the moisture content. Moisture content is a factor of obvious direct concern to seller and buyer alike, and it will always be a basis of price. Good, dry wheat deserves a premium out of direct proportion to the actual dry matter present for the simple reason that drying wheat is often a troublesome and expensive process for the miller. Moreover, drying is necessary since there are fairly close limits to the possible range of moisture content for the satisfactory milling of a given type of wheat, and English wheat frequently exceeds these limits. Further, it is almost always the practice to wash wheats before milling in the interest of flour colour. *Apart from this the miller naturally* prefers not to buy water. Home-grown wheat, the moisture content of which ranges from 14% to 22%, is in

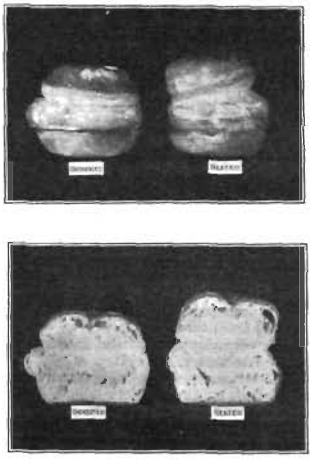


Fig. 4.

Effect of hot damp-air treatment on a straight run bread-making flour made from a mixture of wheats

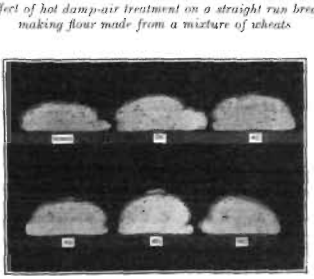


Fig. 5.

Improving action of hot air of different relative humidities on an English (non-Yeoman) flour. Under the particular experimental conditions 60% relative humidity at 140° F. produced the best result (cob loaves)

competition with imported types of moisture content between 9% and 15%. Further, much damage to quality frequently results through the sprouting of wheat in the ricks at wet harvest periods. This problem is being studied at the Institute for Research in Agricultural

Engineering at Oxford, and a convenient form of drier for use on the farm is already on the market.

Summary

In improving the production of home-grown wheat the two prime considerations are yield and quality of grain. With regard to yield little may be expected or will be needed from science in the immediate future—the problem to a large extent has been solved. Much, however, remains to be done by the farming industry *itself in utilizing existing knowledge and experience. There appears to be little reason beyond apathy and lack of organization and leadership why the wheat crop should not be increased threefold in a very few years.*

The other consideration—quality of grain—has been the Cinderella of agricultural research. The brilliant Cambridge effort, which resulted in the development of the Yeoman wheats, was made possible only because the milling and baking investigations necessary to success were carried out by and at the expense of a private firm.

Much remains to be done in improving the quality of our grain—and it must be done if the output of home-grown wheat is to exceed materially that of the peak year of this century, 1918. Improvements may be effected along four lines:

(1) The development and extended use on the farm of wheat-drying machinery.

(2) The development of new varieties of wheat suitable for all wheat growing districts, (*a*) of higher protein *content, and* (*b*) *of improved gluten quality.*

(3) The development in the mills of physical methods of improving the baking characters of flour (flour conditioning processes).

The object to be aimed at should be to produce wheats of such good quality that they may be ground and consumed, with little or no admixture with foreign wheats, in the districts where grown, thereby saving the heavy transport charges characteristic of this country. The fate of the English wheat grower is closely bound up with that of the country miller: the two stand or fall together.

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Discussion

Prof. H. E. Armstrong recalled a series of lectures in which it had been stated to be a very grave question at the moment as to whether the masses were being entirely under-nourished owing to the lack of quality in the bread used. In his youth, he continued, bread was bread, made from a flour which was more or less a wholemeal. Then, unfortunately, came the American [illegible] which gave us starchy material; the next bad step wa[s] the baking combines which resulted in the productio[n] of bread without a crust worth looking at. He con[-] sidered that we should have to get back to the wholemeal bread problem, and he welcomed also Dr. Fisher['s] reference to going back to the local miller and the loca[l] baker: the loss of the local baker was a very grav[e] loss indeed.

As to the difficulties of the wholemeal bread problem he referred to a school at which the boys were give[n] wholemeal bread produced by a local miller and loca[l] baker; it was found however, that they could not g[o] much beyond about 85%, because their young stomach[s] *were too much tickled. These problems must be worke[d]* out to eliminate qualities which were not of grea[t] importance. Unfortunately, the masses had taken t[o] white bread, and it was largely a matter of fashion.

Mr. George King said the problem resolved itself int[o] whether we should continue to import the hard winte[r] Canadian wheats, or whether the British producer coul[d] be persuaded or instructed to produce from Englis[h] wheats flour with a high protein content. An importan[t] point was to determine the effect which the flou[r] improver—nitrogen trichloride—had on the protein con[-] stituents of the flour. At the same time there wer[e] many who would prefer to see the problem tackled fro[m] the agriculturist's rather than from the chemical poin[t] of view. Why was the protein in the hard winte[r] Canadian wheat better than the protein in the Yeoma[n] wheats? Again, it was known that a small quantity o[f] ammonium persulphate would render starch soluble but he could not see any connexion between the glute[n] content of a treated flour and that reaction on th[e] starch, and had not found in the literature any guidanc[e] on that matter. He would be glad if Dr. Fisher coul[d] get to the fundamentals of the problem and could sa[y] exactly what the change was.

Dr. W. H. Gibson (Linen Industry Research Associa[-] tion) said that this problem of the quality of an agricul[-] tural crop was quite general, *i.e.*, it applied to othe[r] crops as well as wheat. Many people had worked on th[e] problem of increasing the quantity of a crop, and qualit[y] might have been arrived at by getting special strains but we did not know very much about the production o[f] quality in an agricultural crop. With arable crops w[e] were always working on a rotation, but we knew ex[-] tremely little about the effect of preceding crops in [a] rotation on subsequent crops, and particularly on th[e] question of quality, so that a great deal more work wa[s] necessary on cultivation. In this connexion he men[-] tioned his own experience in Northern Ireland a year o[r] two ago, where he had grown a crop of Italian hem[p]. It had grown quite well, to a height of 12 ft. or so, an[d] after harvesting the crop he had had a bare patc[h] of soil through the winter, weeds being eliminated. On adjacent land he had grown a sugar-beet crop, an[d] sugar beet was quite beneficial in a rotation. Durin[g] the next season he had grown flax on both these patches o[f] land, and after the same period of growth the fla[x] stems on the hemp patch were about twice as hig[h] as those on the sugar-beet patch. That was a bi[g] difference.

Fisher, commenting on Prof. Armstrong's remarks, that if the public were taught to eat the kind of that our grandmothers had made, we should be to produce the flour. It was no use raving about millers, for they were producing what the public for and demanded; if Prof. Armstrong could made *the public to go back, then the millers would* him friend. If the public wanted wholemeal, it easy to make it; it would be easy to grind it up in a including all the dirt that grandmother used to A mill contained an enormous amount of machinery about one-third of it was concerned with wheat cleaning.

There was *a very sound physiological instinct behind* demand of the manual workers for white bread. calorific value was very much greater than that of brown bread, so that for a man who was doing hard physical work it was a better fuel than brown bread he could get more fuel in a given bulk. The strongest demand for the whitest flour came from the manual workers in the country.

Dealing with Mr. King's remarks concerning the fundamental effects of improvers, he said that nothing was known about the problem. At the present stage we had a general idea of what we wanted and we knew that certain improvers, used in a certain way, would produce certain effects. The effect on the protein we did not know; we did not even know that the effect was on the protein. If the miller milled a single variety of wheat he divided it into various grades. The lower grade *contained more gluten than the* higher grade, but was not so good. It was quite possible that there might be small quantities of certain things present in wheat which determined whether the gluten should be a good one or a poor one.

The problem of cultivation was amazingly complex, involving problems of agricultural practice, manuring, etc. *As an illustration of its complexity, he mentioned* that three or four years ago, when we had had fine harvesting weather, and when everybody had anticipated that crops would be good, he had obtained samples of wheat from different parts of the country and had milled and baked it. The bread produced was indescribably bad. Six weeks later he had obtained samples from the same districts and the same mills—though he could not be sure that they were from the same farms—and they were unusually good. What had happened during the time between the gathering of those two crops?

HOW SCIENCE CAN HELP TO IMPROVE THE NATION'S FOOD SUPPLY—MEAT.*

By J. HAMMOND

INTRODUCTION

If we are going to produce more of our own meat supply in this country we must produce high quality as well as increased quantity, for the British public has fastidious tastes and will not buy food in which the quality is not good. If the quality of one product is good, the public will purchase it to the exclusion of another in which the quality is poor; we prefer to eat good lamb rather than poor beef, and good beef rather than poor mutton.

The problem will therefore be treated in two sections: (1) factors affecting the *quantity* of the product; and (2) factors affecting the *quality* of the product. We will *first consider, however, the relations* between quality and quantity in meat. Like other products, it is often difficult in meat to get the highest quality and quantity combined in one breed. To make the greatest progress in improving the quality of a breed, it is often necessary to reduce its size; but crosses between appropriate breeds form the easiest way of combining *both quality and size in one animal, such*, for example, as the Aberdeen-Angus x Shorthorn cross in cattle.

The public nowadays require small joints; these can be obtained not only by using the smaller breeds of animals, but also by killing the animals at younger ages. In this way the advantages of the increased growth rate and smaller maintenance requirements of the young animal[1] can be taken advantage of. Improvements in feeding and increase in quantity of product should therefore be exploited by reducing the killing age, *rather than by killing larger animals of the same* age, if the full benefits of the progress of scientific feeding are to be utilized. Thus we are now beginning to eat baby beef of 18 months old in place of the 3—4-year-old beef of 50 years ago, and lamb of 4—5 months in place of the mutton of 18—24 months old in those days. Meat produced in this way has not only the advantages *of requiring less feeding stuffs* to produce it, through reduced maintenance requirements, but also offers a quicker turnover of capital and rate of production. Per 1 lb. of saleable meat a bullock of 3 years old has consumed 22½ lb. (dry matter) of food, whereas one killed at 18 months has only consumed 11¾ lb. for each 1 lb. of saleable meat produced.[2] The younger animal, however, requires a higher proportion of concentrated food—2½ lb. as compared with 1¼ lb. for the older animal—so that the efforts of science in producing concentrated rather than bulky feeds off the farm assist these changes in the progress of animal production.

FACTORS WHICH AFFECT THE QUANTITY OF THE PRODUCT

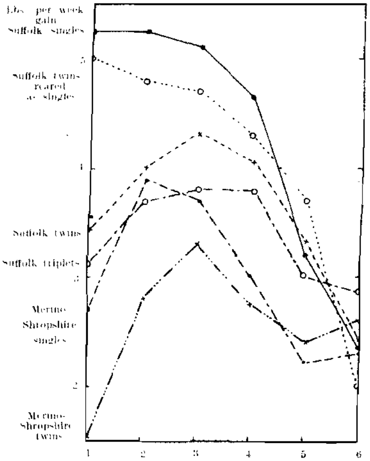
Apart from breed, this is primarily a question of foods and feeding. Again, apart from breed, the rate of growth in most farm animals is limited mainly by the amount and nature of the food supply. The principal factors in feeding to produce meat which need attention at the present time are as follows:

(*a*) *The milk supply of the dam.*—If it is to be fit to kill at an early age it is essential that the young animal gets a good start in life, and for this purpose the milk supply of the dam is most important. For example (see Fig. 1) in Suffolk lambs the rate of growth of twins does not reach its maximum until the third month, whereas that of singles and twins reared as singles attains its maximum in the first month: the lamb has great inherent powers of growth in early life, but the limiting factor in their realization is the milk supply. In addition to breeding and selecting for milk production in our meat-producing animals, we can do much by the feeding of the dam before, as well as after,

* Read at the Food Group Session during the Annual Meeting of the Society in Newcastle, 1933.

parturition. In order to produce milk the mammary gland must develop well, and by feeding on high protein feeds for 6 weeks or so before parturition ("steaming up" in cows) the growth of the gland is encouraged so that more milk is produced when the young are born.

(*b*) *The balance of the ration.*—During the course of growth of the animal the different tissues grow at different rates and mature at different times. Thus, for example, at birth the bone is well developed and makes its maximum growth early; muscle develops later and fatty tissue develops last—as the dia-



(From Hammond and Appleton[3])

FIG. 1

Rate of growth of singles, twins reared as singles, twins and triplets

grammatic curves show (see Fig. 2). The young animal requires, therefore, a high protein ratio in the feed and it is much more efficient in converting the proteins of the feed into meat than is the older animal, but is far less efficient in the conversion of the carbohydrates and fats of the feed into meat than is the older animal. These facts are not yet fully appreciated by those farmers who are gradually changing their system from the fattening of adult to that of younger animals. The baby beef from the Argentine is produced mainly from lucerne which is high in proteins. The need for the balanced ration is particularly evident in the growth of poultry and pigs, where the natural food supply consist mainly of cereals; and with them the feeding of skim milk (the supply of which might be greatly increased if the public could be induced to buy more cream), meat meal, fish meal, and other animal proteins leads to a much greater efficiency in the utilization of the ration. The vegetable proteins present in the cereals and in beans are not so effective as the animal proteins unless minerals are added, when they become almost as effective as animal proteins.[5] The reason for this is not completely understood, but it may be that, since the main proteins of the body are soluble only in dilute salt solutions (globulins etc.), the body cannot build them up into body proteins after digestion unless a sufficiency of these salts is present in the food.

(*c*) *The limitation of bulk.*—Although the ruminant stomach is eminently suited to the digestion of cellulose, the process, carried out as it is by bacterial action, is a slow one. Foods such as hay containing a large amount of fibre are quite suitable for feeding for maintenance or for a low rate of production, but when breeds have been improved for high production the *rate of digestion* is too slow and the stomach space occupied is too large to afford a high rate of food absorption. Woodman, *et al.*[6] have shown that as the plant grows up the proportions change: in the young state the plant contains a high proportion of proteins and salts, later soluble carbohydrates are formed, and as the flowering shoots appear the higher celluloses are produced in increasing proportions. Since in this *latitude the* growth of the plant is seasonal, effective and cheap methods are required for conserving the young plant for feeding purposes during the remainder of the year (ensiling, drying, etc.) in place of the present system of making hay from the plant after large amounts of fibre have developed in it.

(*d*) *The "lightness" of the feed.*—It has been found that, when the bulk of the ration has been reduced by limiting the amount of fibre in it, then it is very important that the concentrated feeds used should be "light."[7] This again is fundamentally concerned with the *rate of digestion*. "Heavy" meals, such as wheat, maize and bean meal, if fed to cattle will become sticky and form a dough in the stomach, and will therefore be slow to digest. Like sumpy bread they lie heavily in the stomach and cause indigestion and reduced appetite. If, instead, "light" feeds such as bran, flaked maize, and sugar-beet pulp are added to the ration the digestive fluids easily penetrate them and they are quickly digested. What we require at the present time is some convenient form of apparatus to produce flaked or puffed grains (such as are used for human breakfast foods) on the farm for animal feeding in place of the grist mill which is at present used. This is particularly required for beans, which, although they show a good chemical analysis, cannot be used in a ration in large amounts owing to their "heaviness." If beans could be flaked, with the addition of small amounts of minerals, they would form just that high protein feeding stuff which is required for the rapid growth of young animals. Possibly further chemical investigation may show other and cheaper means of reducing the stickiness of the starch granules than by flaking or puffing.

FACTORS WHICH AFFECT THE QUALITY OF THE PRODUCT

The quality of a meat-producing animal depends mainly on its proportions. The proportions, not only of the chemical and tissue constituents, but also of the

..rent parts of the body (joints) change as the animal ..s up, and it is these changes which form the main basis ..uality. These changes are shown diagrammatically in .2. In proportion to its height the young pig is all . and legs with only a short and shallow body; but .. grows up the body becomes proportionally larger, .. lengthening and then deepening.[4] Corresponding .these changes in external proportions there is also ..eding a change in composition: the young pig has ..h proportion of bone, as the body lengthens muscle ..eloped, while during the stage of thickening of the .. fat is laid on in increasing amounts. In some ..s (Middle White) these changes proceed faster .. in others (Large White) so that they are ready for ..ng at lower weights. The stage at which they are ..dy for slaughter is when the muscle has grown ..ciently to give a high proportion of muscle to bone

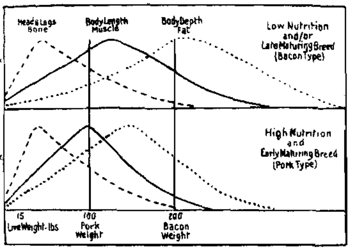


FIG. 2

..grams showing how the changes in body form and composi-.. are brought about by differences in the time and rate of ..wth of different parts and tissues of the body. The upper ..gram shows how growth occurs in a late maturing breed ..on type), or under conditions of a low plane of nutrition; ..le the lower diagram shows these changes in an early maturing ..ed, and under conditions of a high plane of nutrition. The ..ves represent growth of the parts of the body: (1) Head and .., (2) Body length and (3) Body depth—or alternatively of ..y tissues: (1) Bone, (2) Muscle, and (3) Fat. The thick ..tical lines mark off the amount of growth made up to the time . animals have reached pork (100 lb.) or bacon (200 lb.) ..ight; this varies according as the breed is late or early maturing, and as the plane of nutrition is low or high

..d before the fat has developed too much and the ..dy has deepened; this, in the pork type (Middle ..hite) is at about 100 lb. live weight, and in the bacon ..pe (Large White) at about 200 lb. live weight. The ..e at which these changes in the form and composition .the body proceed depends also on the plane of nutri-..n. On a high plane of nutrition the growth curves ..e Fig. 2) of the different parts and tissues are brought ..ser together, as occurs in an early maturing breed, ..ile on a low plane of nutrition they are drawn out, as .a late maturing breed. Consequently we can modify .. animals' composition and proportions, within certain ..its fixed by breed, to fit it for any market according .the plane of feeding adopted.

..The value of the fat in a meat animal depends on the ..sition in which it is deposited in the body. The distribution of fat in the body behaves in the same way as the form and composition of the animal[3]; fat is put on in a definite order—internal (caul) fat first, then subcutaneous fat, intermuscular fat, and lastly marbling fat within the muscles. In the late maturing breeds, and on a low plane of nutrition, only the first is developed to any extent, and this has far less commercial value than that which is put on over the muscles. The colour of the fat is also of some importance, deep yellow fats being disliked: the yellow colour is produced from the xanthophyll pigments of the plant, and grass-fed bullocks have a deeper yellow fat than stall-fed ones. The intensity of the colour under similar conditions of feeding varies in different breeds, the paler colours being dominant over the darker colours in inheritance.

The firmness of the fat is also a quality of considerable commercial importance: it depends mainly on the temperature at which it is laid down in the body[8] and on the type of food supplied. Fat to be of use as a source of energy in the body must be just fluid at the natural body temperature, and as a consequence the fat of cold-blooded animals (fish) is of very low melting point, while the fat of the sheep which has a high body temperature (104° F.) is of higher melting point than that of the bullock with a lower body temperature (101° F.). For the same reason the suet fat has a higher melting point than the subcutaneous fat. Fat synthesized by the animal from carbohydrates produces a firm fat characteristic of the species, but fat produced from fats in the feed are capable of lowering the natural melting point of body fat. The fats in feeding stuffs vary in the same way as animal fats according to the temperature of their deposition: for example, the foods from plants of tropical origin such as palmnut, coconut, and cotton have high melting point fats, while those coming from nearer the poles such as linseed and rape have low melting point fats. We have ample means therefore of controlling the firmness of fat in the animal.

The flavour of meat is closely associated with its colour.[3] White veal is comparatively flavourless while dark bull beef is too highly flavoured to meet the public's taste. Castration reduces the hæmoglobin content not only of the blood but also of the muscle, and so steers have meat of a paler colour and a flavour more suited to the public's taste. Age and exercise also increase the hæmoglobin content of the muscle so that mutton from mountain sheep has more flavour than that from folded lowland lambs. In veal where the production of a white meat is desired, it is necessary to ensure that the food of the calf is deficient in iron (since hæmoglobin cannot be formed without it), milk thus forming the best food; for this purpose other common and cheap feeding stuffs deficient in iron are required as milk substitutes.

What is usually called tenderness, but perhaps better described as lack of coarseness, in meat depends on the fineness of grain or size of the muscle bundles. This in turn, within each species, depends on the size of the muscle fibres[3]; this, and so the size of the muscle bundles, increases greatly with age. Consequently we find that generally speaking the younger animals have the more tender meat, and this forms another reason for killing at younger ages. As a rule also the smaller

the breed and species the less coarse will the meat be, for the muscle bundles will be smaller.

Marketing Organization

Until some better marketing organization for meat comes into existence in this country the application of science to the industry will be slow, for under present conditions the production of good quality meat does not always get its reward.

Under the recently-proposed Bacon Pig Marketing Scheme there would be payment according to quality and the producer will then demand from science the means to secure this. For beef, mutton, and pork, slaughtering in packing houses to supply the retail trader in the large cities would be a more efficient method of marketing our meat than the present one, for the utilization of the by-products could then be carried out scientifically and efficiently.[9] For example, the glands of internal secretion, from which very many valuable medicinal products may be obtained, are for the most part wasted at the present time: if profit is made from these the meat can be sold at the same price, while a better one can be paid to the farmer for the live animal, in addition to the extra employment given.

The broad outlines for the scientific grading of meat are first the division into different classes on a weight basis, for standard sizes are necessary when households have to be supplied with the same sized joint week after week. These classes could then be divided into grades according to quality. Science can supply, as pointed out above, the necessary methods to control the animal for these ends when the organization of marketing is such that their use is effective in obtaining a livelihood for the producer.

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HOW SCIENCE CAN HELP TO IMPROVE THE NATION'S FOOD SUPPLY—FERTILIZERS*

By H. J. PAGE, M.B.E., B.Sc., F.I.C.†

That fertilizers play an important part in crop production is a fact beyond dispute. In the British Isles the consumption of fertilizers in the year 1931 was:—

Nitrogen (N)	46,000 tons
Phosphoric Acid (P_2O_5)	157,000 ,,
Potash (K_2O)	45,000 ,,

* Read at the Food Group Session during the Annual Meeting of the Society at Newcastle.

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But one need only compare these figures with the area of cultivated land to see that although the present part of fertilizers is important, it is small in comparison with the part that they could play. For example, the above consumption of nitrogen corresponds to only about 3 lb., equivalent to 15 lb. of sulphate of ammonia, per acre of cultivated land (excluding hill pastures and rough grazings). A minimum dressing of about 1 cwt. of sulphate of ammonia (or its equivalent) per acre could be applied with safety and with a good return, on practically all arable crops and on grass. Dressings much in excess of this could be, and often are, applied to some of the more intensively grown crops.

The disparity between the actual and the potential consumption of fertilizers is in large measure the result of unfavourable economic conditions in the agricultural industry. The progressive farmer of to-day is well aware of the advantages in increased crops to be gained by a more liberal use of fertilizers, but when, as so often is the case, he is already producing his crops at a loss, he is naturally unwilling to produce more of them. Even though the cash value of the increase in yield exceeds the cost of the fertilizers needed to produce that increase, so that by spreading his total costs over a larger yield he reduces his cost of production per unit and even reduces his total loss, he needs an extra cash outlay to do so, and this is not usually at his disposal. As soon as he is assured of a remunerative price for his produce, by however small a margin, the progressive farmer will be able and only too ready to make a much bigger use of fertilizers. His less progressive brother may then be expected to follow his example and to profit by the ample fund of expert advice that is at his disposal.

While the chief hindrance to the increase in food supply that larger use of fertilizers could bring about is thus to be found in the operation of economic and political factors outside the control of agricultural science, there are none the less many directions in which science can still help to bring about the more efficient use of fertilizers for food production.

The Place of Fertilizers in Increased Food Production

Fertilizers have generally more effect on the yield than on the quality of crops, though in some cases, which are discussed later, the latter effect is of importance.

Soil analysis: its possibilities and limitations.—One of the most insistent problems with which the agricultural chemist is faced is that of adapting his manurial recommendations to variations in soil as between different localities. This country possesses, for its size, a great variety of soils of very widely differing degrees of inherent fertility. When on these inherent differences are superimposed differences in past cultural treatment, marked variations in fertilizer requirements result. In recent years there has been much development of new laboratory methods designed to assess the "plant food requirements" of a soil. The belief of the practical agriculturist that the chemist can give reliable advice purely as a result of analysis of his soil, dies hard: it is still a common experience to receive, from a farm perhaps at the other end of the country, a sample of a few ounces of soil with a request for detailed recommendations as

the manuring of the land in question. Nowadays no agricultural chemist of repute would be so bold as to base such recommendations merely on the basis of a soil analysis. He knows that plant food supply is only one of many factors which may exert a dominant influence on crop production. Detailed knowledge of climate, drainage, method of cropping, and so on, must be available. Given such information, soil analysis can be of great value, but the final touchstone must always consist of actual manurial trials on the land.

The proper function of soil analysis for the diagnosis of the manurial requirements of the soil is in connection with a soil survey, associated with a properly designed scheme of field experiments. When areas of similar types of soil have been mapped, and when the actual plant food requirements of the soil at sufficient centres in any such area have been ascertained by field experiments and correlated with the result of the analysis of the soil at these same centres, then it is possible, from the analysis of soil from anywhere else in that area, to give a pretty reliable opinion as to the need for nitrogen, phosphoric acid or potash on that soil for any specified crop. But the analytical criteria of deficiency may differ greatly between different soil areas. An extreme example may serve to illustrate this point. In this country a soil containing less than 0·01% of P_2O_5 soluble in dilute citric acid under the conditions of Dyer's test is likely to suffer definitely in crop-producing power if not given a phosphatic fertilizer, yet there are instances of tropical soils containing only a small fraction of this amount of citric-soluble P_2O_5 that yet grow good crops with no added phosphate and show no response to the latter.

This emphasizes the necessity of using soil analysis in conjunction with the results of properly designed field experiments at typical centres.

When all is said and done, however, despite the great developments in agricultural science, practical agriculture remains essentially an art—already a highly developed one, and capable of still further development with the aid of science as its handmaiden. It can never, especially as regards crop production, become an industry controlled by exact science in the same way as an industrial manufacturing process. It would be manifestly impossible to provide a special fertilizer with an $N : P_2O_5 : K_2O$ ratio carefully adjusted to the supposed requirements of each of the individual soils of this country in all their wide variety. The needs of all crops and soils can be met sufficiently closely for the conditions of ordinary farming practice by a strictly limited number of fertilizer formulæ with only a few steps in the ratio of $N : P_2O_5 : K_2O$. If by a combination of soil analysis and field experiment in any given soil area an analytical figure can be fixed as marking approximately the distinction between deficiency and sufficiency of a given plant food, there need then be little difficulty in selecting from a dozen or so standard recommendations, one which is suited for any given crop on the soil in question.

The agricultural scientist in this country is seriously hampered in this direction by the lack of co-ordinated schemes of field experiments. Many European countries are far ahead of us in this respect, and although in recent years some progress has been made by the conduct of field experiments up and down the country, as for instance by Rothamsted and by Jealott's Hill, there is a real need for a more comprehensive scheme, worked in conjunction with the soil survey work which is now in active progress. British workers have led the field in producing greatly improved methods of plot experimentation, and it is regrettable that less use is being made of these improved methods for the purpose under discussion, in the country of their origin, than in many other countries.

Balance in fertilizers.—The importance of "balance" in manuring, *i.e.*, in ensuring that the full efficiency in the action of a given dressing of plant food is not hampered by the deficiency of another, needs little emphasis now. The Rothamsted work on the manuring of the potato is the best known example of this, showing how increasing dressings of either nitrogen or of potash cannot produce adequate increases of crop unless the dressing of the other is likewise increased in due proportion. Similar results have since been obtained with other crops (*e.g.*, sugar beet) at Jealott's Hill and elsewhere. Not only is this knowledge now utilized in modern practice in the manuring of farm crops, but it is also embodied in fertilizer manufacturing practice in the composition of a range of concentrated fertilizers manufactured in this country, containing a suitable balance of N, P_2O_5 and K_2O for British crops and soils.

Concentrated fertilizers.—Concentrated fertilizers represent a notable advance in fertilizer practice. By the use of mono-ammonium phosphate as a source of all the P_2O_5 it is possible to make "compound" fertilizers containing the desired ratios of $N : P_2O_5 : K_2O$, in which the content of these "plant foods" is double or more than double that in the equivalent ordinary mixtures of sulphate of ammonia, superphosphate and potash fertilizers. This concentration, combined with the fact that they are made in a granular form, results in obvious advantages in saving in freight and handling costs, ease of application and so on. Comprehensive field experiments have demonstrated that the manurial effectiveness of these fertilizers is on the average at least as high as that of the equivalent ordinary mixtures.

A notable difference between these concentrated fertilizers and the lower-grade ordinary mixtures is that the former owe their concentration to the absence of the calcium salts that make up such a high proportion of the superphosphate in the latter. Not only is the phosphoric acid in superphosphate present as a calcium salt, but also roughly half the material consists of calcium sulphate. While for the majority of soils this calcium in the ordinary mixtures is not needed, it is possible that in certain cases it is useful; in such cases concentrated fertilizers might be at a disadvantage in this respect. Experimental work is being carried out on this problem, in order that, if necessary, steps may be taken to remedy this possible defect and thus enable full benefit to be reaped, even under exceptional conditions of soil and climate, from the undoubted advantages which concentrated fertilizers are known to possess

and which can already operate unhampered on the majority of soils.

"Minor" elements: their possible importance in manuring. Related to the above problem is that of the practical importance of the so-called "minor" elements in crop production. Work under controlled conditions in water and sand culture has definitely established that in addition to the four "major" elements (nitrogen, phosphorus, potassium and calcium), some dozen or so other elements are essential, or if not essential, are beneficial to plant growth. Usually, however, only the "major" elements are likely to be lacking in cultivated soils, and it is the primary function of fertilizers to supply the first three, and of "liming" by means of calcium oxide or carbonate to supply the calcium.

The essential or beneficial "minor" elements are usually thought to be present in the soil in sufficient amount to supply the needs of the crop. This is certainly the case to the extent that complete crop failure or obvious limitation of crop due to lack of a minor element from the soil, is not of general occurrence. Provided other conditions are favourable, the supply of the nutrient needs of the crop by a fertilizer containing all or some of the three major nutrients, N, P_2O_5 and K_2O, is usually adequate to ensure satisfactory yields. But of recent years there has been an increasing number of cases in which failed or poor crops have been traced to a lack of a "minor" element. Manganese and copper are cases in point. Most of such cases have so far been recorded from other countries, but recently cases of crop failure due to manganese shortage have been reported in this country.

Is it not possible that a partial deficiency of minor elements may play a much more extensive part than has hitherto been suspected? It has been said that for every case of say arsenical poisoning in which the culprit is brought to justice, there are probably many more cases of successful or attempted arsenical poisoning that remain undetected. May there not similarly be many areas on which the crops, though perhaps doing reasonably well, are being prevented from yielding as well as they might, and from utilizing fully the N, P_2O_5 and K_2O available to them, by an unsuspected partial shortage of a minor element? This possibility merits serious investigation, for it has obviously important bearings on fertilizer manufacture and practice and on the possibility of increasing the supply of home-grown food.

So long as adequate supplies of farmyard or stable manure were available, the possibility just discussed was less likely to be of practical importance, for the vegetable residues contained in the manure would return to the soil to a greater or less extent the minor elements taken from it by the plant; but now that the farmer is increasingly dependent on fertilizers for feeding his crops, a progressive depletion of essential minor elements from the soil is much more possible, and it may be that the greater incidence of cases of proved minor element shortage is in part due to the increased use of fertilizers and not merely to more active and widespread investigations. Fortunately, as soon as any such deficiency is established—and modern methods of spectrographic analysis render the solution of such problems very much easier than formerly—it is a comparatively simpl matter to supply the practical remedy.

How far can fertilizers replace organic manures?—As just pointed out, this question of minor elemen content is one of the factors bearing on the large problem of the extent to which fertilizers can replac organic manures, but there are many other facets to thi problem. It is generally acknowledged by agricultura scientists, though less generally appreciated by practica farmers, that there are two quite distinct aspects to th problem.

So far as the supply of plant food to the growing cro is concerned, there is, with one possible exception, n function of organic manures that cannot or could not b equally well and in some cases better performed b fertilizers. The essential inorganic elements neede by the plant can all be supplied by inorganic fertilizers These elements may be and often are released fron organic manures in the soil and rendered available t the crop at rates different from what is the case wit inorganic fertilizers. This difference is sometimes defi nitely to the disadvantage of the organic manures. In some other circumstances, notably for some horti cultural crops, the reverse is the case, and the slowe release of nitrogen from some organic manures is o advantage. This opens up the possibility of the manu facture of slower-acting synthetic fertilizers for use unde such conditions.

The possible exception referred to above is that organi manures may release small quantities of organi substances that exert a definitely growth-promoting o similar accessory effect on plants, akin to the action o vitamins and hormones in the animal. It is now recognized that plants may absorb through their root a much greater variety of nitrogenous and organi substances than was supposed a few years ago. Whil this is far short of a return to the old "humus" theory of plant nutrition of the early days, it may well be tha substances similar to the "auximones" postulated b Bottomley are after all of real importance in plan nutrition. This may help to explain the very specia regard in which organic manures are held by man specialized growers, particularly under glass, and th superlative levels of quality and yield that they ca often attain; but it is, in my opinion, doubtful whethe this will ever be a matter of any practical importanc under ordinary farming conditions.

The function of organic manures that cannot b taken over by fertilizers is that of influencing favourabl the physical texture of the soil, and thus promotin "tilth" and favourable moisture conditions, by buildin up and maintaining the supply of so-called "humus," the characteristic organic colloid of the soil. The exten to which this function is of importance in practice ma vary greatly. Probably the effect on moisture supply i the most important, and when natural conditions ar such that adequate water is assured, as for example b a high and adjustable water table as in Holland, or b a plentiful and well distributed rainfall, it is highl questionable whether the maintenance of the soi organic matter by the use of organic manures is of muc practical importance. But under the more genera conditions of a strictly limited and often precariou

... r supply, this function of organic manures may ... a marked influence on crop yields.

Alternative methods of maintaining the supply of organic matter by special systems of cropping are ...able and are used in certain cases, but there is still ... real need for a generally applicable practical ...stitute for farmyard or stable manure, especially in ...tricts where water is scarce. Meantime, however, ... appear to be no good grounds for believing that ... production cannot be maintained at satisfactory, ... perhaps at improved levels, by the use of fertilizers ... with dressings of dung that are much less than ... customary in the past.

Before leaving the subject of organic manures, it is ...able to point out a common error. Many growers ... their faith on organic manures in the belief that they ... all useful sources of "humus" in the soil. It is com...only overlooked that only the *vegetable* material in ...ganic manures is of value in this respect, the humus ...ound being derived from the cellulosic and woody ...ssues of vegetable residues.

Animal manures of essentially a protein nature, such ... dried blood, high-grade shoddy and the like, which are ...ee from material of vegetable origin, may, perhaps, ...der some circumstances have advantages over inor...anic fertilizers in their direct nutritional effect as ...iscussed above, but there is no evidence that they are ... themselves of any value as sources of "humus" in ... soil. The distinction is one between "bulk" ...anures and organic nitrogenous manures, and it is ... distinction of much practical importance that is ...mmonly overlooked.

Fertilizers in relation to mechanized farming and ...ntinuous cereal growing.—The present-day tendency ... the development of mechanized farming and con...nuous cereal growing is raising new problems in ...anuring. Although continuous cereal growing will ...sult in the production of much more straw, and ...erefore of ample supplies of material capable of ...rving as a source of organic matter in the soil, the ...ractice of a system excluding the use of the horse, and ... which live-stock play little or no part, results in the ...bsence of facilities for turning that straw into bulk ...imal manure on the farm. If the straw is ploughed ...w into the soil, it is liable to have a depressing effect ... the crop, by stimulating the growth of soil micro-...ganisms which, in multiplying, temporarily deplete ...e soil of available nitrogen to the detriment of the ...op. There is reason to believe that this effect can be ...ercome by using dressings of nitrogenous fertilizers ...ng with the straw when it is ploughed in. Hitherto ...s has been a problem of secondary importance, but it ... now likely to have an increasing practical bearing in ...lation to the maintenance of the soil organic matter in ...echanized farming.

The dressings of nitrogen that would accompany ...oughed-in straw would of course be applied in the ...tumn. Even when straw is not so applied, however, ...tumnal dressings of nitrogen may still be required. ...utumn-sown wheat, when grown in the rotation, ...ually receives all its nitrogen fertilizer as a spring ...p-dressing, and the available evidence shows this to ... preferable to autumn application. But it must be remembered that wheat grown in the rotation is likely to have available in the soil sufficient amounts of nitrogen as residues from sheep-folding, ploughed-in sod, or from a liberally-manured previous crop. Wheat on land devoted to continuous cereal growing will not have these residues, and it may very well prove that a part at least of its nitrogen should be applied in the autumn.

Crop varieties and fertilizers response; "lodging" of cereals.—Another aspect of the use of fertilizers for increased food production is in relation to the development of improved varieties of crops. Varieties of higher yielding capacity take more out of the soil, and so necessitate increased dressings of fertilizers to enable them to yield to their full capacity, and for the maintenance of soil fertility. Moreover, there is some evidence that some of the newer varieties of cereals, for example, respond more generously to manuring, and so increase the power of fertilizers to add to the yield of food produced per acre. Perhaps the most important aspect of the relation of fertilizers to crop varieties, however, is in connection with the "lodging" of cereals. On the whole, wheat does not receive anything like such big dressings of fertilizers as it could make use of for increased grain production, because the straw of most of the older and well-established varieties is not strong enough to carry the increased crop of grain, so that the plant becomes "laid" before harvest, with consequent serious loss of or damage to the grain and greatly increased difficulty in harvesting. Some of the newer varieties are much superior in this respect, and will stand up and give good responses to dressings of fertilizers much in excess of those that can be safely used on the older varieties.

Grassland manuring in relation to milk and meat production: grass preservation.—Much work has been carried out in this country on the manuring and management of grassland in the past seven or eight years, and much of this has been so much written about, and is so well known, that I shall not discuss it in detail here. The possibilities of a balanced complete manuring as part of an intensive system of grassland management have been demonstrated experimentally, and are being adopted to an increasing extent in practice.

Fertilizers can add very materially to the production of herbage of high nutritive value on pastures, not only during the normal grazing season, but they can greatly increase the amount of grazing available when it is most valuable—in early spring and late autumn. Important as this is in relation to increased and cheaper production of meat and milk during the grazing season, it has equally big possibilities as regards the feeding of stock during the winter. For certain parts of the grazing season, the grazier commonly has a considerable surplus of growth that he cannot utilize at the time without using many more stock than he can carry through the rest of the grazing season or through the winter. Some of this surplus he can and does make into hay, but much of it is produced at a time when haymaking is difficult or impossible. Moreover, hay at the best is a low-grade feeding stuff, not capable of taking the place of the concentrated foods needed for milk- or meat-

production. Surplus grass cut at a younger stage of growth has a much higher feeding value, for its dry matter, than hay, and is indeed no longer a coarse fodder, but a concentrated food comparable with the oil cakes which form such a large part of the concentrate ration. If therefore, satisfactory means of preserving this surplus grass, while it is still in a young and highly nutritious stage, can be found, the surplus is turned from an embarrassment into a boon for the farmer, and more fertilizers can be used with advantage to increase its yield.

The bigger the amount of good analysis grass that can be preserved for winter use, the greater the saving in the use of imported oilcakes and other purchased concentrated foods. The possibilities of grass preservation as a means of making milk- and meat-production less dependent on imported feeding stuffs are enormous, and it is not too much to say that of economic methods of preservation of the increased produce from properly manured grassland can be developed, they will bid fair to work as big a revolution in British Agriculture as did the introduction of fertilizers themselves.

This is not the occasion to deal in detail with methods of grass preservation. Suffice it to say that much work has been and is being done on two alternative methods—artificial drying, and preservation without drying by the use of improved methods of ensilage or allied processes such as the A.I.V. process, in which mineral acids in controlled amounts are used as aids to preservation.

The Place of Fertilizers in the Production of Better Food

So far I have dealt with the effect of fertilizers on quantitative aspect of food production. This is the main function of fertilizers, to give bigger yields of crops, meat or milk. Provided these bigger yields are of unimpaired quality, full advantage can be taken of the increased production. If properly used, fertilizers do not impair quality, and cases where such impairment occurs can usually be shown to be due to improper use—often by an ill-balance of N to P_2O_5, and K_2O, or to application in excessive amounts or at the wrong time.

In many cases fertilizers used in the right way may bring about an improvement in quality. In general however, quality in food crops is primarily a function of climatic and soil conditions and of variety. If these are favourable, a good quality crop will be obtained, however it is manured, within reason, while if the environmental factors are conducive to poor quality, no kind of manuring will do much to improve it.

Grass preservation in relation to the quality of milk and butter.—There is one important direction, however, in which fertilizers can indirectly exert a pronounced effect on the quality of animal products, namely milk and butter. This is another aspect of the use of preserved grass for winter feeding of cows. Grass can be dried artificially or preserved wet as silage or A.I.V. fodder, so that its effect on the colour and vitamin-*A* potency of the butter-fat or the milk of cows fed on it is equal to that of summer grazing. Instead of the pale milk and pallid butter commonly produced from stall-fed cows in the winter, a richly coloured milk and a bright yellow butter are produced, and the extra colour is a real index of a higher nutritive value by virtue of the proportionately higher vitamin-*A* content and potency. Th the production of more preserved grass for winter feedin by the use of more fertilizers on grassland, would repr sent a definite and important contribution towards t improvement in the quality of one of the most importa of all known foods—milk.

Fertilizers in relation to the "mineral" content animal and human foods.—The quality of food crops a depends on their content of "minerals" or ash co stituents, notably lime and phosphates. Not only this of importance in human nutrition but also fa stock in some districts may suffer from a deficiency certain "minerals" in the soil and therefore in t food they eat. This is of special importance overse as for instance in South Africa and New Zealand, i there are areas in this country, notably some hill pastu in Scotland, where "mineral" deficiency is a cause malnutrition in stock. The proper use of mine fertilizers on such land may do much to remedy su defects and so to increase both the quality of food cro (including grass) and the productivity of farm stock.

Although not coming strictly within the title of t paper, mention may be made briefly of the use of ot chemicals allied to fertilizers for improving food prod tion. The control of insect pests and fungoid disea by sprays, washes, dusts, etc., the eradication of we by acid and other chemicals, the use of acids in gr preservation, already mentioned, are all notable examp of this.

Weather forecasting and crop insurance in relation the use of fertilizers.—Another way in which science c assist in the use of fertilizers for increased food p duction has been emphasized recently by Sir J Russell. Adverse weather conditions may milit seriously against the effectiveness of increased dressi of fertilizers, so that expenditure on this head may *brought to naught after their application.* Althou it will probably be many years before meteorologi science can give entirely reliable forecasts of the com season's weather, such forecasts can now be made w more certainty than formerly. Moreover, much m work is needed on co-ordinated schemes of fi experiments in different parts of the country, and the statistical examination of existing records of fi experiments, for the study of the relation betw weather conditions, especially rainfall, and fertili response on different soils in different districts. Wl sufficient information of this kind is available it sho be possible to prepare tables on the basis of wh farmers, or fertilizer firms, could insure against the r of failure of crops to respond to fertilizers owing adverse weather conditions. This is another direct in which science—in this case actuarial science a meteorological science—can help towards increa food production.

Economic Considerations

I have cited many examples of the ways in wh science has helped toward increased food producti and other ways in which further progress in this direct can be hoped for. I do not propose to attempt estimate of the actual increase in food production this country that could be obtained by an increa use of fertilizers. Several such estimates have b

...e, notably one by Sir Frederick Keeble ("Fertilizers ... Food Production," Oxford University Press, 1932, 7s. 6d.). According to this estimate, by the use of moderately increased dressings of fertilizers, Great ...ain and Northern Ireland could produce 55% of all food consumed, instead of only 38% as at present. ...ill paid by the nation for imported food would ...be reduced by not less than 100 millions sterling. ..., as I have already emphasized at the beginning, ... considerations are all over-shadowed by the ...orable economic situation of the farmer. So ... as this exerts its crippling influence, agriculture ...nce, while it can help in some measure to alleviate ...severity of its effect, has no chance of enabling ...culture to receive more than a tithe of the benefits it ...ady has to offer. If economic and political science ...properly so called, let us hope that the signs of ...provement in the prosperity of British agriculture, ...which the first glimmerings seem to be dimly appearing, ... develop into a real economic revival under the ...uence of political assistance scientifically applied, ...d that thus economic and political science will live ...to its name and do its fair share along with agriculture ...helping science to improve the nation's food supply.

CORRESPONDENCE

THE SLOW OXIDATION OF AROMATIC HYDROCARBONS AT HIGH PRESSURES

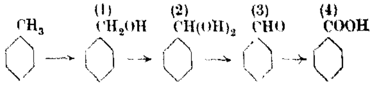
SIR,—Recent work from these laboratories[1] has ...own that when paraffin hydrocarbons are oxidized ... high pressure alcohols, aldehydes, and acids are ...rmed and, under suitable conditions, survive in large ...antities in the products of combustion. The results ...e satisfactorily accounted for on the supposition that ...e hydrocarbon molecule undergoes hydroxylation ...hereby the above products are successively formed.

It is of importance to ascertain if the oxidation of ...omatic hydrocarbons takes place by a similar mechan...n. In the case of benzene there is little doubt but ...at the initial product of oxidation is phenol and ...ferences are repeatedly found in the literature to the ...tection of this compound amongst its oxidation pro...ucts.

The liquid and vapour phase oxidation of toluene ... ordinary pressures, however, gives benzaldehyde, ...nzoic acid, and anthraquinone; the benzene nucleus ...es not appear to undergo direct hydroxylation and ...e presence of benzyl alcohol has hitherto not been ...ported.

We have recently carried out experiments on the ...xidation of toluene by means of air at a temperature of ...0° C. and at pressures of 50 atmospheres. The re...tion proceeds smoothly and approximately 60% of the ...luene burnt appears as hydroxylated compounds in ...e products which consist chiefly of benzyl alcohol with ...mall quantities of benzaldehyde, 2 : 4 dihydroxytoluene ...nd benzoic acid.

The occurrence of benzyl alcohol together with ...hydroxytoluene is of special interest as indicating ...hat both the aromatic nucleus and the aliphatic side ...hain may simultaneously undergo oxidation, the ...echanism being one of hydroxylation. Thus in the case of the aliphatic side chain oxidation would proceed as follows:



the first stage being detectable only under high pressure conditions.

We are, Sir, etc.,

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July 26, 1933

[1] Proc. Roy. Soc., 1931, **A**, **134**, 591; 1933, **140**, 426.

SYNTHESIS OF ASCORBIC ACID

SIR,—We have now succeeded in showing by synthetic methods that ascorbic acid is built up in accordance with the structure previously allocated to this important substance by one of us (Hirst and co-workers, CHEMISTRY AND INDUSTRY, March 10, 1933, p. 221; Hirst, Percival, and Smith, Nature, 1933, **131**, 617). We have submitted both *d*- and *l*-xylosone to the action of aqueous potassium cyanide containing also calcium chloride. Contact from 10 to 20 minutes with these reagents effected the addition of hydrogen cyanide and simultaneous hydrolysis to the corresponding carboxylic acid with liberation of ammonia. The calcium was removed by the addition of oxalic acid in quantitative amount, and the solution was evaporated in presence of free acetic acid. Extraction with alcohol effected a separation from mineral matter. The product liberated by cold 1% hydrochloric acid is a powerful reducing agent, reducing iodine in acid solution, and shows an absorption band at 275 mμ. This substance is not ascorbic acid, since it gives a different crystalline phenylhydrazine derivative, and an essential stage in the synthesis must now be introduced, namely, the transformation of this product by digestion with 8% hydrochloric acid at 50°. After this treatment the substance shows the correct absorption band in acid solution at 245 mμ, and in neutral solution as sodium salt at 265 mμ. It has all the other properties, such as reduction of iodine, silver nitrate, copper acetate, etc. characteristic of ascorbic acid and yields a yellow diphenylhydrazone (osazone) m.p. 210° as originally described by one of us (Hirst, CHEMISTRY AND INDUSTRY, *loc. cit.*). The osazone is obtained after conversion of the synthetic ascorbic acid to its oxidation product with iodine and represents the most accessible and characteristic derivative of ascorbic acid.

The stages involved in the synthesis are those already outlined (Haworth, CHEMISTRY AND INDUSTRY, June 9, 1933, pp. 482—485) by the formulæ there quoted under (A) ⟶ (B) ⟶ (C) ⟶ (IV). The complete verification of the identity of structure of the synthetic product with that of the natural substance has been obtained in this laboratory by Mr. Cox by *X*-ray methods. He finds that there is not the least doubt that the structure of the synthetic and natural ascorbic acid in the form of their phenylhydrazine derivatives is the same.

The synthetic work has been carried out by a staff of workers. The following have been engaged with the

d-enantiomorph: D. K. Baird, H. C. Carrington, R. W. Herbert, E. G. V. Percival, and M. Stacey. Work on the *l*-enantiomorph has been conducted by R. G. Ault, E. G. V. Percival, F. Smith, and M. Stacey who have carried out the laborious work of preparing *l*-lyxose from *d*-galactose through the following series of transformations: *d*-galactose diacetone → *d*-galacturonic acid diacetone → *d*-galacturonic acid → *l*-galactonolactone → *l*-galactonamide → *l*-lyxose → *l*-lyxose phenylosazone → *l*-lyxosone (*l*-xylosone), involving the conversion of several kilos of galactose into the final *l*-xylosone. We have found that the yield of the addition product with potassium cyanide is superior to that with liquid hydrogen cyanide and that the same initial addition product with absorption band at 275 mμ is obtained in each case. Transformation to ascorbic acid occurs by subsequent digestion with hydrochloric acid. By the same procedure we have also synthesized, with R. J. W. Reynolds and M. Stacey, an analogue of ascorbic acid in the *d*-glucose series.

There can therefore be little doubt that the synthetic product obtained by Reichstein, Grussner, and Oppenauer (Helv. Chim. Acta, 1933, **16**, 561) was a derivative of *d*-ascorbic acid although, as one of us has already pointed out (CHEMISTRY AND INDUSTRY, 1933, p. 482—485), the formulation previously ascribed by these authors to the synthetic stages from xylosone cannot be supported. It is now evident that to them belongs the credit of having published the first account of a synthetic derivative of the *d*-enantiomorph of ascorbic acid.

W. N. HAWORTH and E. L. HIRST

Birmingham University
Aug. 1, 1933

PERSONAL AND OTHER ITEMS

We regret to learn of the death in America of Mr. H. W. Reed, who had been associated with the dyestuffs industry for 50 years. He was for many years manager in Boston of the General Dyestuffs Corporation, and for 16 years was manager and director of the Badische Co.

Edinburgh University Court has approved an arrangement whereby Dr. Neil Campbell, lecturer in organic chemistry in the University, and Dr. L. A. Bigelow, assistant professor of organic chemistry, Duke University, North Carolina, will exchange duties during the 1933—34 session.

Prof. A. A. Read is retiring at the end of the present session from the position of Professor of Metallurgy and Fuel Technology at the University College of South Wales. Prof. Read will have completed 40 years in the service of the college. He will be succeeded by Dr. W. R. D. Jones, who has been appointed lecturer in metallurgy.

The University of London has conferred the degree of D.Sc. (engineering) on Mr. P. Dunsheath, who is research and technical manager of W. T. Henley's Telegraph Works Co., Ltd. Dr. Dunsheath is a well-known member of the London Section of the Society.

We regret to learn of the death recently of Mr. W. F. Cuming, who was for many years a member of the Society in Australia. Mr. Cuming was a grandson of the founder of Cuming, Smith & Co., manufacturer[s of] chemicals and fertilizers. He became manager o[f the] firm in 1920, and on its amalgamation with the M[t.] Lyell Chemical Works & Federal Fertilizers, Ltd[. in] 1929 he was appointed managing director of the [new] company, Commonwealth Fertilizers & Chemi[cals,] Ltd. He was a member of the Council of Melbou[rne] University and vice-president of the Melbourne Cham[ber] of Manufacturers.

Prof. H. W. Florey, M.B., M.A., has been appoint[ed to] the Sir William Dunn Chair of Pathology, tenabl[e at] Guy's Hospital Medical School. Since 1931 he has [been] Joseph Hunter Professor of Pathology in the Univer[sity] of Sheffield.

The Council of the Oil and Colour Chemists' Asso[cia]tion has accepted with regret the resignation of [Mr.] M. E. Dougherty from the office of honorary treas[urer] of the Association. He will be succeeded in the aut[umn of] this year by Mr. H. D. Bradford.

Prof. J. B. Conant, president-elect of Harvard Uni[ver]sity, has been elected an Honorary Fellow of Emma[nuel] College, University of Cambridge.

Beit Fellowships for Scientific Research

The trustees of the Beit Fellowships for Scien[tific] Research have awarded Fellowships for one y[ear,] renewable for a second year, for research at the Imp[erial] College of Science, London, to: Mr. S. F. Boys, [B.Sc.] (Imperial College), for experimental research conne[cted] with the structure of molecules and some probl[ems] linked with these in the light of modern chemistry [and] physics, under Prof. J. C. Philip, F.R.S.: Mr. [M.] Blackman, M.Sc. (Rhodes University College, So[uth] Africa, and the University of Göttingen), for rese[arch] on the theory of crystal structure and molecular vi[bra]tion in crystals, under Prof. S. Chapman, F.R.S.: Mr. H. B. Squire, B.A. (Oxford), for research into [the] stability of certain viscous fluid motions, under [Prof.] L. Bairstow, F.R.S.

In addition, the Fellowships awarded last yea[r to] Dr. R. M. Shackleton, Mr. E. G. Jones, and Dr. R[.] Rosenberg (cf. CHEM. & IND., July 15, 1932, p. [...]) have been extended for a second year.

Institute of Metals

The Silver Jubilee Autumn Meeting of the Insti[tute] of Metals is to be held this year in Birmingham f[rom] September 18 to 21. On the first day of the meeting [Mr.] W. R. Barclay, O.B.E., vice-president of the Instit[ute,] will give the twelfth Autumn Lecture on "Twenty-[five] Years' Progress in Metallurgical Plant."

Nitrate Producers' Conference

A conference was held recently in Paris between representatives of the Chilean nitrate interests and representatives of the European synthetic nitrate [pro]ducers, but was abandoned without any agreem[ent] having been reached. The principal point under [dis]cussion was understood to be the renewal of the ag[ree]ment between producers which expired on June 30[.]

Canadian Chemical Industry

The Dominion Bureau of Statistics at Ottawa [in a] report dealing with "The Petroleum Products Indu[stry] in Canada, 1932," records an output value during [the] year of $71,697,757, as compared with $76,158,64[...] 1931 and $91,787,205 in 1930.

Mines Branch of the Dominion Department of at Ottawa has issued Memorandum No. 58 by B. Timm and M. H. Haycock, describing the minera- laboratory, where microscopic and spectroscopic mination of ore samples and mill products is con- ed in connexion with the work of the ore dressing metallurgical laboratories.

During 1932 the production of platinum, palladium, other metals of this group was valued at $1,991,472. ing of practically all the Canadian output of these which occur with the nickel-copper ores of is carried on at Acton, England. A small ount of stream platinum is produced in British umbia, and the nickel-copper matte which is shipped Norway from Canada carries values in platinum metals.

Preliminary figures show that the production of zinc ring last year in Canada totalled 172,283,558 pounds ued at $4,144,454. British Columbia is by far ada's principal zinc-producing province. Manitoba come to the front as a zinc producer during the st two years since the construction by the Hudson Mining and Smelting Co., Ltd., at Flin Flon, lanitoba, of a zinc refinery in conjunction with their pper smelter.

panese Production of Camphor

The production of raw camphor in the year ending larch 31, 1932, is given as 3·54 million lb., as against 58 million lb. in the previous year. The figures for mphor oil for the two years are 15·92 and 17·27 llion lb., respectively. About 60% of the production n Formosa.

COMPANY NEWS

NATIONAL CANNING CO., LTD.

The combined net profits of the company and its bsidiary Wisbech Produce Canners, Ltd. during the ar *ended May 31 amounted to £56,644, after provision* r depreciation but not for taxation, as compared with 1,537 in the previous year. The company proposes pay *a dividend of* 7½%, less tax, as *compared* th 12½% dividend for the period January 13, 31—May 31, 1932, and a reserve fund of £25,000 is be *inaugurated. During the year the company* quired a controlling interest in British Fish Canners, d., which has a paid-up capital of £17,501. The *rectors are putting forward resolutions for increasing* authorized capital by £100,000, by the creation of cumulative preference shares of £1.

COKE OVEN PRODUCTS, LTD.

A new company with the name Coke Oven Products, td. has been registered, the subscribers to the memo- ndum including the South Yorkshire Chemical Works, horncliffe Coal Distillation Co., United Steel Co., Mr. E. G. West (of Newton Chambers & Co.), Mr. C. F. ard-Jones (of Yorkshire Engine Co.), and others. The mpany is limited by guarantee, having no share pital, and the original number of members is limited 50. The objects are to carry on the business of ners, manufacturers, distillers, etc., and dealers in products produced in connexion with coke ovens, llieries, gas and chemical works, and to carry on the siness of oil and spirit distillers and refiners etc.

MARKET REPORT

This Market Report is compiled from special information received from the manufacturers concerned.

Unless otherwise stated, the prices quoted below cover fair quantities net and naked at sellers' works.

The following alterations in prices are reported since the publication of the last Market Report (cf. CHEM. & IND., July 7, 1933, p. 569).

TAR PRODUCTS

Acid Cresylic, 99/100.—11d.—1s. 8d. per gal., according to specification. Refined, 1s. 8d.—**1s. 9d. per gal.** Pale, 98%, 1s. 4d.—1s. 5d. per gal. 95%, 11d.—**11¼d. per gal. Dark, 10d. per gal.**

Toluole.—90%, 2s. 2d.—2s. 3d. per gal. Pure, 2s. 6d. per gal.

PHARMACEUTICAL AND PHOTOGRAPHIC MATERIALS

Seidlitz powder (pulv.).—55s.—58s. 9d. per cwt.

Sod. Potass. Tartrate (Rochelle Salt).—65s. per cwt. **net for 1-ton lots. Crystals, 2s. 6d. per cwt. extra.**

Citral.—7s. per lb.

ESSENTIAL OILS

Eucalyptus, Australian B.P., 70/75%.—1s. 2d. per lb. **Huon Pine (Methyleugenol, 95%), 16s. per gal.** Lavender.—Mont Blanc, 38/40%.—10s. 9d. per lb. Lemon.—4s. 6d. per lb. Lemongrass.—4s. 3d. per lb. Orange, Sweet.—6s. 6d. per lb. Otto of Rose.—***Anatolian, 37s. 6d. per oz.; Bulgarian, 55s. per oz.*** Palma Rosa, 8s. per lb.

PATENT LIST

The following is a list of complete specifications of chemical interest which are open for inspection under Section 91 (4) (*a*) of the Patent Acts. Printed copies are not available, but photographic copies may be obtained at a charge of 8d. per page (minimum 1s.) from the Patent Office, Chancery Lane, W.C.2.

I. 36,484 (1932). Pease, Anthony Equipment Co. *See* II.

II. 5000 (1932). Koppers Co. of Delaware. *See* VII.

36,484 (1932). Pease, Anthony Equipment Co. *System for scrubbing a gas.*

III. 32,539—43 (1932). Reichsmonopolverwaltung f. Branntwein. *See* XVIII.

35,854 (1932). Usines de Melle, and Guinot. See XVIII.

981—3 (1933). I. G. Farbenind. Manufacture of hydroxythionaphthens and indigoid dyestuffs derived therefrom.

IV. 512 (1933). Durand & Huguenin A.-G. Manufacture of azo dyestuffs.

981—3 (1933). I. G. Farbenind. *See* III.

V. 934 (1933). Brit. Celanese, Ltd. Manufacture and treatment of artificial materials.

VI. 934 (1933). British Celanese, Ltd. *See* V.

1109. (1933). Soc. Chem. Ind. in Basle. Dyeing and other treatment baths for textile materials containing animal fibres.

1418. (1933). I. G. Farbenind. Manufacture of weatherproof luminous substances.

VII. 5000 (1932). Koppers Co. of Delaware. Manufacture of ammonium sulphate.

401 (1933). Grah. *See* XVI.

1102 (1933). I. G. Farbenind. *See* XIII.

1418 (1933). I. G. Farbenind. *See* VI.

IX. 1091–6 (1933). Johns-Manville Corp. Structural unit porous material, and adhesive composition therefor.

1418 (1933). I. G. Farbenind. *See* VI.

X. 194 (1933). Esser. Producing industrial iron *by means of iron sponge.*

XIII. 1102 (1933). I. G. Farbenind. Manufacture of pigments.

XIV. 28,364 (1932). Goodyear Tire & Rubber Co. *Vulcanization of rubber.*

XV. 1109 (1933). Soc. Chem. Ind. in Basle. *See* VI.

XVI. 401. (1933). Grah. Fertilizing salts.

XVIII. 32,539–43 (1932). Reichsmonopolverwaltung f. Branntwein. Dehydrating alcohols by azeotropic distillation.

35,854 (1932). Usines de Melle, and Guinot. Rectification of alcohol.

635 (1933). Braasch and Braasch. Production of yeast.

XIX. 22,072 (1932). Hanseatische Mühlenwerke A.-G. Production of concentrated milk products.

30,032 (1932). Heller and Stanek. Manufacture of a fodder.

1083 (1933). Adler. Manufacturing soya milk and its derivatives.

XXI. 1048–50 (1933). Hudeley and Lagrave. Obtaining positive images giving natural colour.

1197 (1933). Breton. Development of photographic papers by ammonia.

GENERAL NOTES

Official Trade Intelligence

The Department of Overseas Trade (Development and Intelligence), 35, Old Queen Street, London, S.W.1, has received the following inquiries for British goods. British firms may obtain further information by applying to the Department and stating the specific number. *Poland:* Piperazine cryst. (200–300 kg.), glycerophosphate salts (200–300 kg.), bromide salts (300 kg.), iodide salts (1000 kg.), quinine salts (200—250 kg.), guayacol preparations, (*a*) potassium-sulpho-guayacol, (*b*) liquid guayacol (200 kg.), caffein, pure (200 kg.), theobromine, pure (1500 kg.), lactose (200—300 kg.) (F.1818). *South Africa:* Leadless white paint in paste (B.Y.7622). *Tunisia:* Soap, colouring powders and materials for dyeing, copper (113).

Safeguarding of Key Industries

The Board of Trade has received complaints under Section 1 (5) of the Safeguarding of Industries Act, 1921, that insulin and its salts, carotene, and sulphur (precipitated, B.P.), have been improperly excluded from the List H (iii) of articles chargeable with duty under Part I of that Act, as amended by Section 10 of the Finance Act, 1926. The complaints will be referred for arbitration to a tribunal constituted under Section 10 (4) of the Finance Act, 1926, and the date of the hearing will be announced in due course. Any communications should be addressed before August 29 to the Principal Assistant Secretary, Industries and Manufactures Department, Board of Trade, Great George Street, London, S.W.1.

Industrial Equipment

Mining & Industrial Equipment, Ltd., report having received orders for the following equipment: *England*—No. 0000 Raymond pulveriser for grinding magnesium oxide; 3 ft. diam. Raymond air-separating plant for separating hydrated lime; 6 ft. by 5 ft. 3-sur. Hum-mer electric screen for screening ground cork, 40-ft. Spitzkasten. *Cyprus*—2-in. and 3-in. grit pumps for handling abrasive mud in either sulphuric acid or cyanide solution. *Rotterdam and India*—Ro-Tap testing sieve shakers for laboratory testing.

Patent Service for Chemists

A little booklet published by the Imperial Patent Service, of First Avenue House, High Holborn, London, W.C.1, will be found useful by inventors of chemical plant, foodstuffs, therapeutics, etc. The principal of the Service is Mr. M. E. J. Gheury de Bray, who has had many years' experience of patents work, first as head of the chemical department of an important firm of chartered patent agents, and in recent years as a patent agent himself.

Gas-cleaning Plant at Corby

In the new steel works of Messrs. Stewarts and Lloyds, Ltd., now being erected at Corby, there is to be installed a *Lodge-Cottrell electrostatic precipitation plant for* cleaning the blast-furnace gas. This gas will be used in the new works partly for mixing with, and partly to replace, the rich coke-oven gas. The cleaning plant will be capable of treating 5,500,000 cb. ft. an hour at N.T.P. and will clean down to a guaranteed figure of 0·0068 grains of dust per cb. ft.

Foyle's Technical Catalogue

Foyle's technical catalogue has helped many chemists in the past, and a new edition will therefore be of interest. It includes more than 100 closely printed pages and every branch of pure and applied science has its list of books. Many good books are offered second-hand, usually at about half the cost of the unused copies, and this gives the opportunity for saving a considerable amount of money, especially when buying the volumes of Newton Friend, Richter, and many others, the cost of which is to be reckoned more often in pounds than in shillings. Copies of the catalogue can be obtained from W. & G. Foyle, Ltd., 119—125, Charing Cross Road, W.C.2.

Aluminium in the Gas Industry

A well-printed booklet published by the British Aluminium Co., Ltd., of Adelaide House, King William Street, London, E.C.4, with the name "Aluminium in the Gas Industry," will be found of interest to both producers and consumers of gas. The first part of the booklet shows how aluminium can be used with advantage in gas washers and purifiers, and for the gas holder aluminium paint has many advantages. Corrugated aluminium is useful in the construction of sulphate houses, coke grounds, etc., where, although only small quantities of sulphur compounds may be present, they may be sufficient to cause comparatively quick destruction of wooden buildings. On the side of the consumer, aluminium is now used for many purposes in ovens, coppers, gas fires, etc., and in industry for commercial lighting, furnaces, paints, etc. The booklet contains a number of good illustrations.